
Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek TMDLs for *E. coli* Bacteria

Final TMDL Report

February 25, 2008

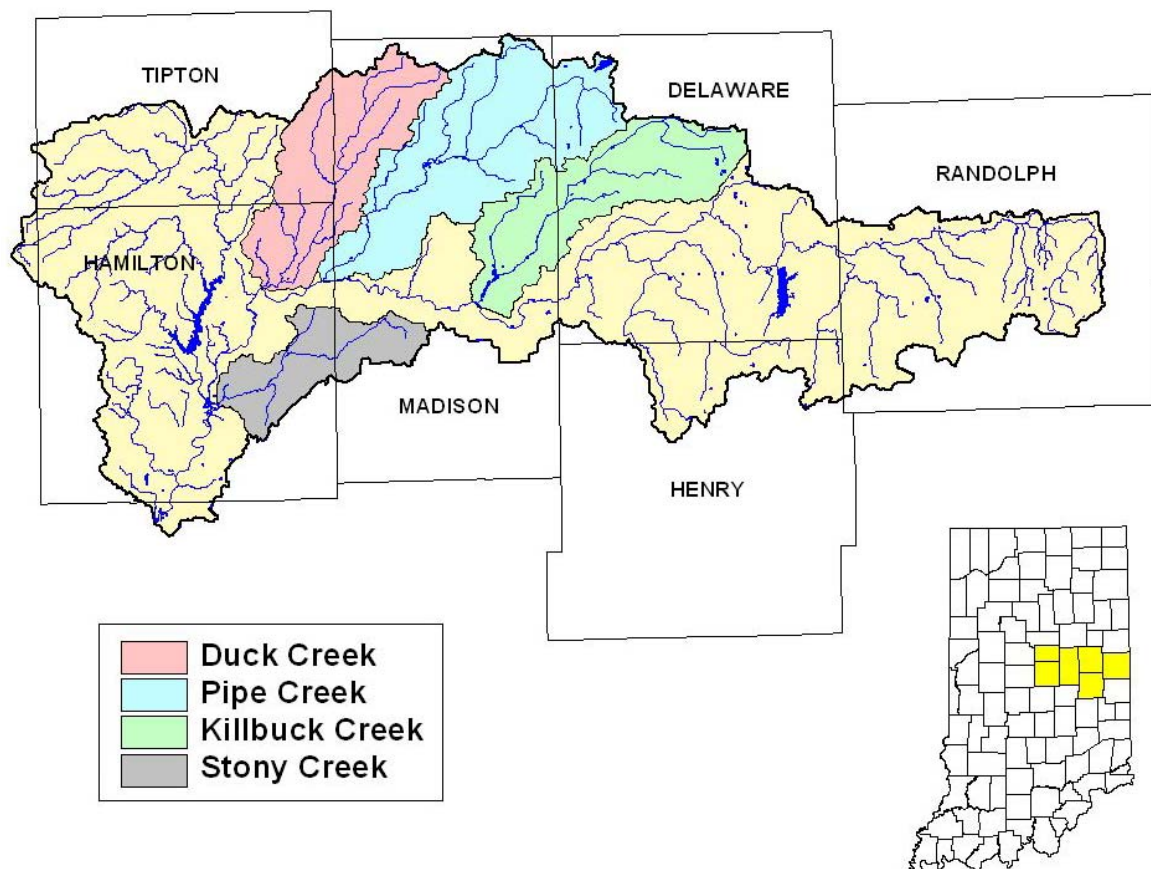


TABLE OF CONTENTS

1.0	INTRODUCTION	1-1
1.1	BACKGROUND	1-1
1.2	NUMERIC TARGETS	1-3
2.0	DESCRIPTION OF THE WATERSHEDS	2-1
2.1	POPULATION	2-5
2.2	TOPOGRAPHY	2-6
2.3	LAND USE	2-10
2.4	SOILS	2-15
2.5	ROW CROP PATTERNS	2-20
2.6	PRECIPITATION	2-22
2.7	HYDROGRAPHY	2-24
2.8	HYDROLOGY	2-27
3.0	INVENTORY AND ASSESSMENT OF WATER QUALITY INFORMATION	3-1
3.1	EVALUATION OF DATA USING THE GEOMETRIC MEAN STANDARD	3-3
3.2	EVALUATION OF DATA USING THE SINGLE SAMPLE STANDARD	3-3
3.3	WATER QUALITY DATA USED IN TMDL APPROACH	3-5
4.0	SOURCE ASSESSMENT	4-1
4.1	POINT SOURCES	4-1
4.1.1	WASTEWATER TREATMENT PLANTS	4-1
4.1.2	COMBINED SEWER OVERFLOWS	4-8
4.1.3	ANIMAL FEEDING OPERATIONS	4-14
4.1.4	MS4 STORMWATER COMMUNITIES	4-14
4.1.5	STRAIGHT PIPES	4-15
4.2	NONPOINT SOURCES	4-15
4.2.1	SEPTIC SYSTEMS	4-15
4.2.2	AGRICULTURE	4-18
4.2.3	WILDLIFE	4-27
4.2.4	DOMESTIC PETS	4-28
5.0	TECHNICAL APPROACH	5-1
5.1	INCREMENTAL WATERSHED LDC APPROACH	5-2

TABLE OF CONTENTS

5.2	CONCLUSION FOR INCREMENTAL WATERSHED LDC APPROACH	5-2
6.0	ALLOCATIONS	6-1
6.1	DUCK CREEK TMDL	6-3
6.2	PIPE CREEK TMDL	6-3
6.3	KILLBUCK CREEK TMDL	6-3
6.4	STONY CREEK TMDL	6-3
6.5	WASTE LOAD ALLOCATION	6-3
6.6	LOAD ALLOCATION	6-4
6.7	COMPREHENSIVE ASSESSMENT	6-4
7.0	MARGIN OF SAFETY	7-1
8.0	SEASONAL VARIABILITY	8-1
9.0	PUBLIC PARTICIPATION	9-1
10.0	REASONABLE ASSURANCE	10-1

REFERENCES

APPENDICES

APPENDIX A – WATER QUALITY DATA

APPENDIX B – WATER QUALITY DURATION CURVES

APPENDIX C – INCREMENTAL WATERSHED LDC TABLES AND FIGURES

FOR THE DUCK CREEK, KILLBUCK CREEK, AND STONY CREEK TMDLS

APPENDIX D – SINGLE SAMPLE STANDARD LOAD DURATION CURVES

APPENDIX E – GEOMETRIC MEAN LOAD DURATION CURVES

APPENDIX F – LOAD REDUCTIONS

APPENDIX G – INCREMENTAL LOAD ALLOCATION INFORMATION AND
ESTIMATED REDUCTIONS

LIST OF TABLES

1-1	Waterbody Segments Listed as Impaired for <i>E.coli</i> Bacteria in 2004 that are Addressed by this <i>E.coli</i> TMDL	1-5
2-1	Comparison of 1990 and 2000 Census Population Data for 10 Communities within the Four Watersheds	2-5
2-2	Land Use Distributions in the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek Watersheds	2-14
4-1	NPDES Facilities with the Potential to Discharging <i>E. coli</i> to the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek Watersheds	4-3
4-2	USDA Cow, Pig, and Sheep Populations in Delaware, Hamilton, Madison, and Tipton Counties	4-17
4-3	Calculated Percentages of Each County within the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek Watersheds	4-17
4-4	Estimates of Cow, Pig, and Sheep Populations within the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek Portions of Delaware, Hamilton, Madison, and Tipton Counties	4-17
4-5	Estimates of Non-CAFO, Non-CFO Related Cow, Pig and Sheep Populations within the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek Portions of Delaware, Hamilton, Madison, and Tipton Counties	4-18
4-6	Active CAFOs/CFOs in the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek Watersheds	4-19

LIST OF FIGURES

1-1	Study Area for the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek Watersheds	1-4
1-2	Spatial Extents of the <i>E. coli</i> Impairments in Each of the Four Watersheds	1-6
2-1	Spatial Extent of the Duck Creek Watershed, with Associated Communities	2-1
2-2	Spatial Extent of the Pipe Creek Watershed, with Associated Communities	2-2
2-3	Spatial Extent of the Killbuck Creek watershed, with Associated Communities	2-3
2-4	Spatial Extent of the Stony Creek watershed, with Associated Communities	2-4
2-5	Shuttle Radar Topography Mission (SRTM) Elevations for the Duck, Pipe, Killbuck, and Stony Creek TMDL Study Area	2-6
2-6	SRTM Elevations for the Duck Creek Watershed	2-7
2-7	SRTM Elevations for the Pipe Creek Watershed	2-8
2-8	SRTM Elevations for the Killbuck Creek Watershed	2-9
2-9	SRTM Elevations for the Stony Creek Watershed	2-10
2-10	NLCD Land Cover Classifications for the Duck Creek Watershed	2-11
2-11	NLCD Land Cover Classifications for the Pipe Creek Watershed	2-12
2-12	NLCD Land Cover Classifications for the Killbuck Creek Watershed	2-12
2-13	NLCD Land Cover Classifications for the Stony Creek Watershed	2-13
2-14	STATSGO Hydrologic Soil Group Categories for the Duck Creek Watershed	2-16
2-15	STATSGO Hydrologic Soil Group Categories for the Pipe Creek Watershed	2-16
2-16	STATSGO Hydrologic Soil Group Categories for the Killbuck Creek Watershed	2-17
2-17	STATSGO Hydrologic Soil Group Categories for the Stony Creek Watershed	2-17
2-18	STATSGO Drainage Classification Categories for the Duck Creek Watershed	2-18
2-19	STATSGO Drainage Classification Categories for the Pipe Creek Watershed	2-18
2-20	STATSGO Drainage Classification Categories for the Killbuck Creek Watershed	2-19
2-21	STATSGO Drainage Classification Categories for the Stony Creek Watershed	2-19
2-22	2001 NASS Row Crop Distributions for the Duck Creek Watershed	2-20

LIST OF FIGURES

2-23	2001 NASS Row Crop Distributions for the Pipe Creek Watershed	2-21
2-24	2001 NASS Row Crop Distributions for the Killbuck Creek Watershed	2-21
2-25	2001 NASS Row Crop Distributions for the Stony Creek Watershed	2-22
2-26	Monthly Precipitation in 2001 at Three NCDC Gages near Subject Watersheds	2-23
2-27	Annual Precipitation at Three NCDC Gages near Subject Watersheds	2-23
2-28	Daily Precipitation Values at Muncie Municipal Airport during the Water Quality Assessment Period of April – July 2001	2-24
2-29	NHD Appended Hydrography for the Duck Creek Watershed	2-25
2-30	NHD Appended Hydrography for the Pipe Creek Watershed	2-26
2-31	NHD Appended Hydrography for the Killbuck Creek Watershed	2-26
2-32	NHD Appended Hydrography for the Stony Creek Watershed	2-27
2-33	USGS Flow Stations in the Study Area	2-28
3-1	Locations of Impairments and IDEM Water Quality Monitoring Sites	3-2
3-2	Violations of the Geometric Mean Standard for Water Quality Monitoring Stations	3-4
4-1	NPDES Facilities in the Duck Creek Watershed	4-4
4-2	NPDES Facilities in the Pipe Creek Watershed	4-5
4-3	NPDES Facilities in the Killbuck Creek Watershed	4-6
4-4	NPDES Facilities in the Stony Creek Watershed	4-7
4-5	CSO Locations in the Duck Creek Watershed	4-9
4-6	CSO Locations in the Pipe Creek Watershed	4-11
4-7	CSO Locations in the Stony Creek Watershed	4-13
4-8	Active CAFO/CFO Locations in the Duck Creek Watershed	4-20
4-9	Active CAFO/CFO Locations in the Pipe Creek Watershed	4-21
4-10	Active CAFO/CFO Locations in the Killbuck Creek Watershed	4-22

LIST OF FIGURES

4-11	Active CAFO/CFO Locations in the Stony Creek Watershed	4-23
------	--	------

1.0 INTRODUCTION

Section 303(d) of the Federal Clean Water Act and the United States Environmental Protection Agency's (USEPA's) Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations (CFR), Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting Water Quality Standards (WQS). TMDLs provide states a basis for determining the pollutant reductions necessary from both point and nonpoint sources to restore and maintain the quality of their water resources. The purpose of this TMDL is to identify the sources and determine the allowable levels of *Escherichia coli* (*E. coli*) bacteria that will result in the attainment of the applicable WQS in the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek watersheds in Tipton, Madison, Delaware, and Hamilton Counties, Indiana.

1.1 **BACKGROUND**

The Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek watersheds in central Indiana all drain to the West Fork White River. Figure 1-1 shows the locations of these four watersheds within the upper portion of the larger West Fork White River basin, encompassed by Tipton, Madison, Delaware, and Hamilton counties. The watersheds range in size from approximately 57 square miles (Stony Creek) to approximately 153 square miles (Pipe Creek). Agriculture is a major activity within the area and row crops and pasture lands account for 80 to 95 percent of the land coverage in each of the four watersheds.

The State of Indiana's 2004 Section 303(d) list of impaired waters (IDEM, 2004) shows that the mainstem waterbodies in each of the four watersheds fail to support the state's recreation use. Table 1-1 shows the specific 303(d) listings for these waters and Figure 1-2 illustrates the spatial extents of the impairments.

Water quality data collected by the Indiana Department of Environmental Management (IDEM) in 1996 and 2001 showed that these waters failed to meet state water quality standards for *E. coli*. The presence of *E. coli* bacteria in surface waters typically indicates that human sewage and/or animal waste have been introduced into the waters. Potential sources of *E. coli* include municipal wastewater treatment plants, failing or illicitly connected septic systems, combined sewer overflows, stormwater runoff, wildlife, livestock, and domestic pets.

The U.S. Environmental Protection Agency (EPA) requires that states develop Total Maximum Daily Loads (TMDLs) for all receiving water impairments included on the States' 303(d) lists. A TMDL is the mass loading of a pollutant that a water body can assimilate from all contributing sources while still maintaining water quality standards and supporting its designated uses. The U.S. EPA has established a project to develop *E. coli* TMDLs for the four watersheds in this study. Goals of the project are to:

- Collect existing data, models, and other information necessary to characterize the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek watersheds, with respect to the impairments listed in Table 1-1,
- Use IDEM approved guidance and policies in developing TMDLs for the four watersheds,
- Evaluate an innovative and cost-effective approach to establish the *E. coli* loading reductions required to meet the receiving stream's designated uses,
- Identify potential management practices that can be implemented to realize the loading reductions,
- Maintain contact with public stakeholders to ensure that the most appropriate information available is utilized, and that key concerns are addressed, and
- Submit draft and final TMDL reports to the U.S. EPA for review and approval.

1.2 **NUMERIC TARGETS**

The impaired designated use for the waterbodies in the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek watersheds is for total body contact recreational use during the recreational season, April 1st through October 31st.

327 IAC 2-1-6(d) establishes the total body contact recreational use *E. coli* Water Quality Standard (WQS¹) for all waters in the non-Great Lakes system as follows:

E. coli bacteria, using membrane filter (MF) count, shall not exceed one hundred twenty-five (125) per one hundred (100) milliliters as a geometric mean based on not less than five (5) samples equally spaced over a thirty (30) day period nor exceed two hundred thirty-five (235) per one hundred (100) milliliters in any one (1) sample in a thirty (30) day period.

The NPDES permit, *E. coli* effluent limits, in the non-Great Lakes system during the recreational season, April 1st through October 31st, are also covered under 327 IAC 2-1-6(d).

For the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek watersheds during the recreational season (April 1st through October 31st) the target levels are set at the *E. coli* WQS of (a) 125 per one hundred milliliters as a 30-day geometric mean based on not less than five samples equally spaced over a thirty day period and (b) 235 per one hundred milliliters for any single sample.

¹ *E. coli* WQS = 125 cfu/100ml or 235 cfu/100ml; 1 cfu (colony forming units)= 1 mpn (most probable number)

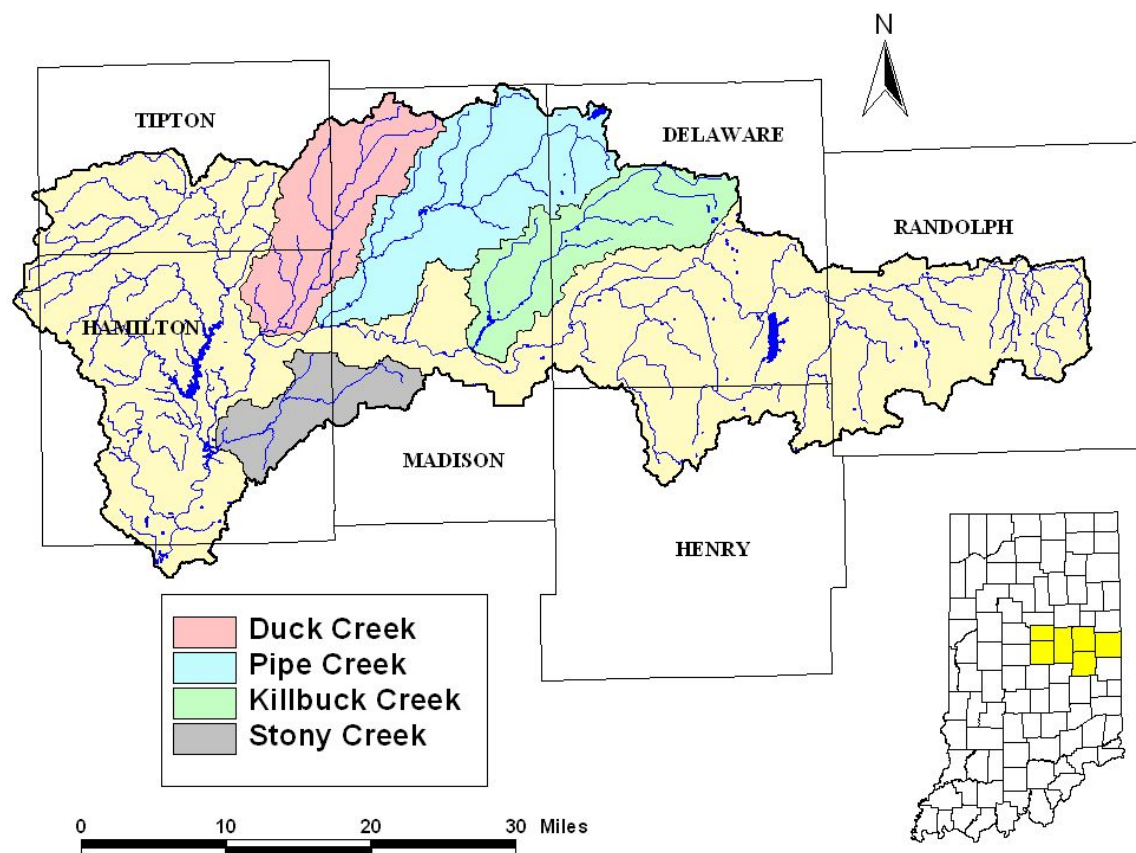


Figure 1-1. Study Area for the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek watersheds

Table 1-1. Waterbody Segments Listed as Impaired for *E.coli* Bacteria in 2004 that are
Addressed by this *E.coli* TMDL (IDEM, 2004)

Stream Name	Impairment	Segment ID
Killbuck Creek	E. coli	INW0141_00
Killbuck Creek - Thruston Ditch	E. coli	INW0142_00
Jakes Creek - Eagle Branch	E. coli	INW0143_00
Killbuck Creek - Pleasant Run Creek	E. coli	INW0144_00
Killbuck Creek	E. coli	INW0145_00
Killbuck Creek	E. coli	INW0145_T1016
Little Killbuck Creek - Nelson Brook	E. coli	INW0146_00
Killbuck Creek - to mouth	E. coli	INW0147_T1017
Indian Creek (Madison)	E. coli	INW0149_00
Pipe Creek - Yeager Finley Menard Ditch	E. coli	INW0151_00
Pipe Creek	E. coli	INW0152_00
Pipe Creek	E. coli	INW0152_T1020
Pipe Creek	E. coli	INW0153_T1021
Pipe Creek	E. coli	INW0154_T1022
Pipe Creek	E. coli	INW0156_T1023
Pipe Creek	E. coli	INW0157_T1024
Pipe Creek	E. coli	INW0158_T1025
Pipe Creek - Hamilton County	E. coli	INW0159_00
Pipe Creek - Swanfelt Ditch to County Line	E. coli	INW0159_T1026
Duck Creek - Todd Ditch	E. coli	INW0161_00
Little Duck Creek basin	E. coli	INW0162_00
Duck Creek - Elwood to Little Duck Creek	E. coli	INW0162_T1028
Big Duck Creek	E. coli	INW0162_T1228
Polywog Creek	E. coli	INW0163_00
Duck Creek - Little Duck Creek to Polywog Creek	E. coli	INW0163_T1029
Duck Creek	E. coli	INW0164_T1030
Bear Creek - West Fork Bear Creek	E. coli	INW0165_00
Duck Creek	E. coli	INW0166_00
Duck Creek	E. coli	INW0166_T1031
Long Branch	E. coli	INW0166_T1227
Sugar Run and other tributaries	E. coli	INW0172_00
Stony Creek - Headwaters	E. coli	INW0174_00
Stony Creek - William Lock Ditch Tributaries	E. coli	INW0175_00
Stony Creek	E. coli	INW0175_T1039
William Lehr Ditch and other tributaries	E. coli	INW0176_00
Stony Creek	E. coli	INW0176_T1040
North Trib - Noblesville	E. coli	INW0177_00
Stony Creek	E. coli	INW0177_T1041

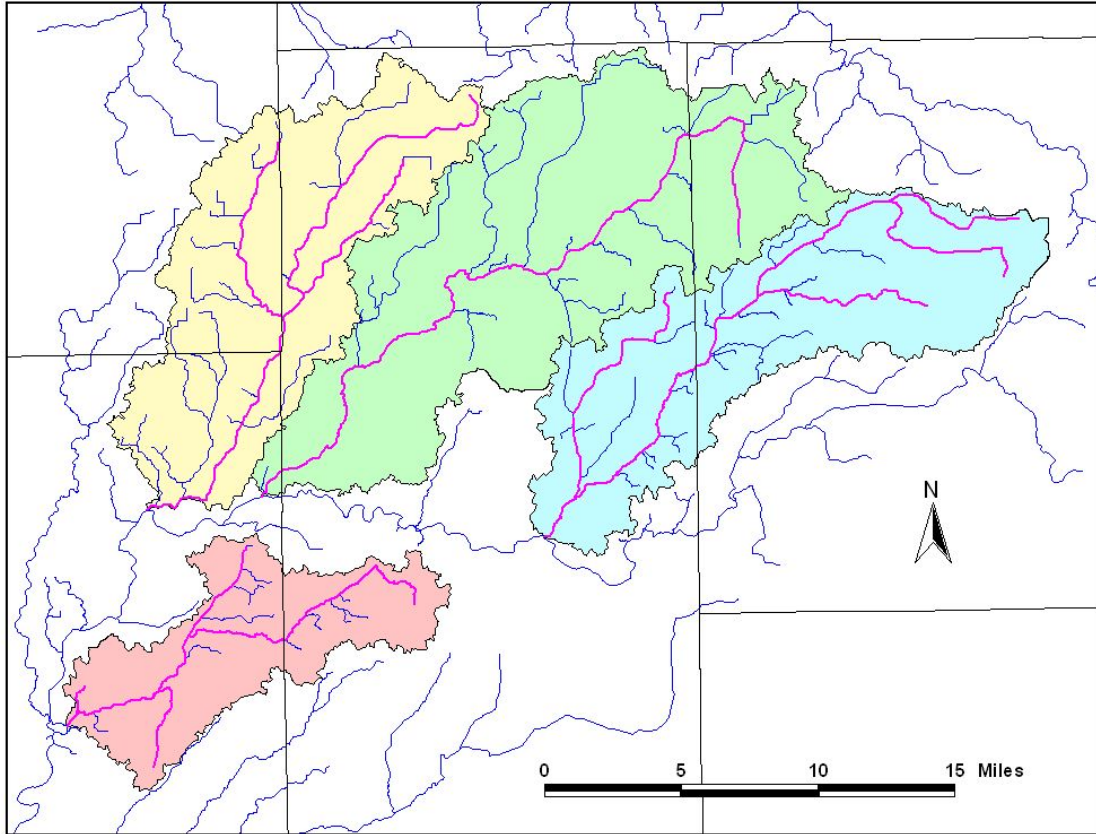


Figure 1-2. Spatial Extents of the *E. coli* Impairments in Each of the Four Watersheds

2.0 DESCRIPTION OF THE WATERSHEDS

The Duck Creek watershed encompasses approximately 105 square miles and includes portions of Tipton, Madison, and Hamilton counties (Figure 2-1). One incorporated urban center, the city of Elwood, is completely situated within the Duck Creek watershed boundary. The major tributaries within the Duck Creek watershed are Little Duck Creek, Polywog Creek, Bear Creek, and Lamberson Ditch.

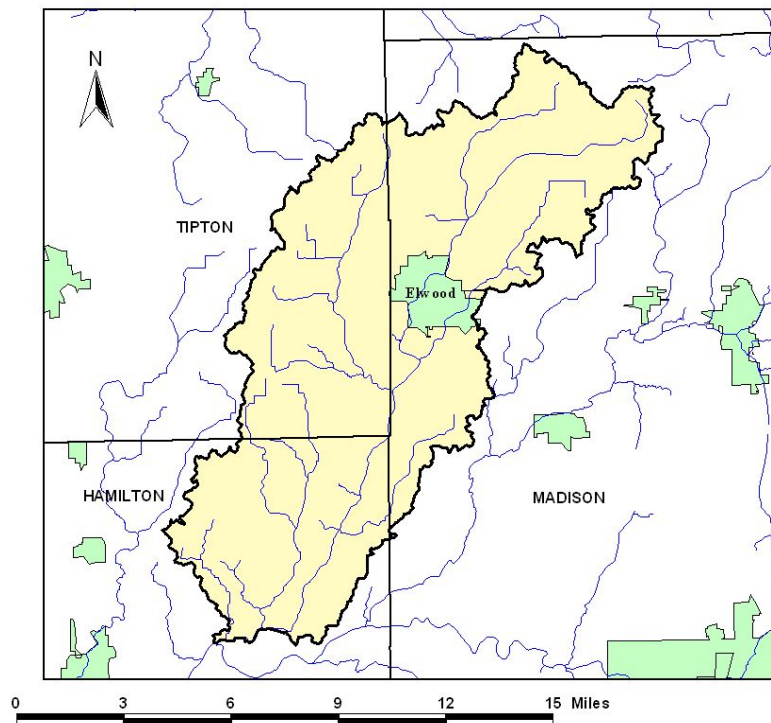


Figure 2-1. Spatial Extent of the Duck Creek Watershed, with Associated Communities.

The Pipe Creek watershed is the largest of the four watersheds (approximately 153 square miles) and spans across Hamilton, Madison, and Delaware counties (Figure 2-2). The Pipe Creek watershed completely encompasses the city of Alexandria, the towns of Frankton, Summitville, and Orestes, and partially includes the town of Gaston. Major tributaries within the Pipe Creek watershed are Mud Creek, Lilly Creek, and Alexandria Creek.

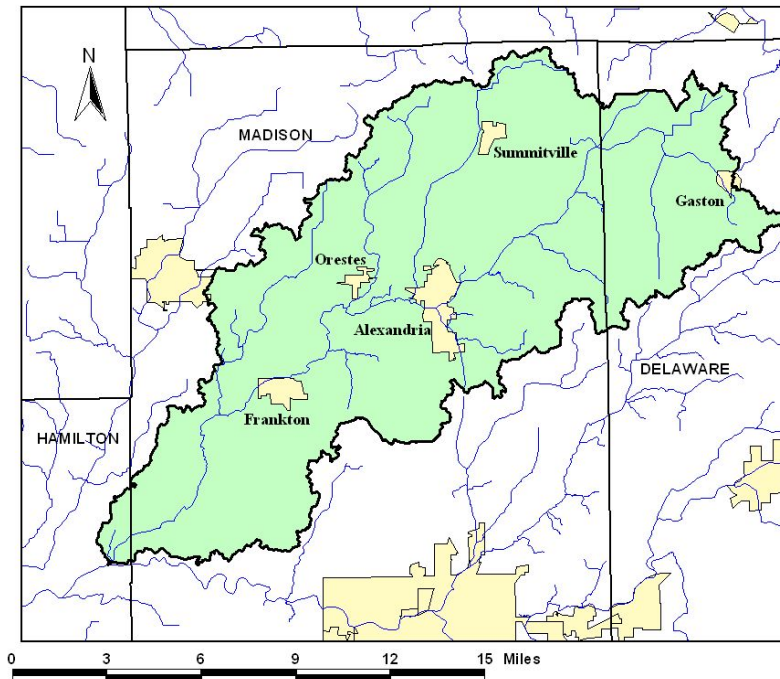


Figure 2-2. Spatial Extent of the Pipe Creek Watershed, with Associated Communities.

At approximately 104 square miles in area, the Killbuck Creek watershed is somewhat more urbanized than the Duck and Pipe Creek watersheds, and includes parts of Madison and Delaware counties (Figure 2-3). While the watershed does not completely surround any municipalities, two of the larger cities in the area, Muncie and Anderson, are partially contained within the watershed. The major tributaries in the Killbuck Creek watershed are Little Killbuck Creek, Mud Creek, Jake's Creek, and Pleasant Run Creek.

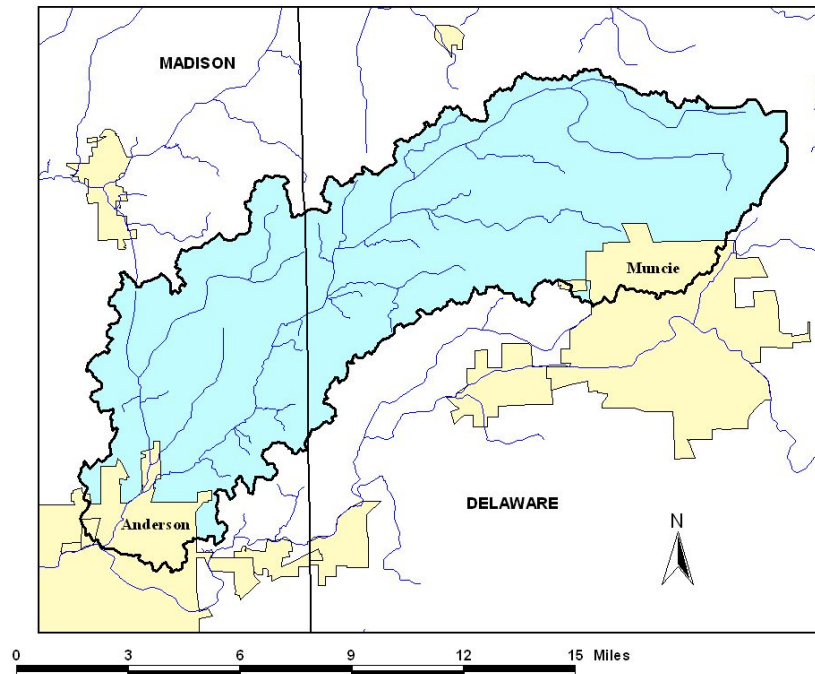


Figure 2-3. Spatial Extent of the Killbuck Creek Watershed, with Associated Communities.

The Stony Creek watershed is the smallest of the four watersheds (approximately 57 square miles) in this study and is approximately evenly split between Hamilton and Madison counties (Figure 2-4). The town of Lapel is completely situated within the Stony Creek watershed boundary. The larger city of Noblesville, is partly within the boundary of the watershed. The upper Stony watershed also includes a small portion of the city of Anderson. The major tributaries in the Stony Creek watershed are the William Lock Ditch and the William Lehr Ditch.

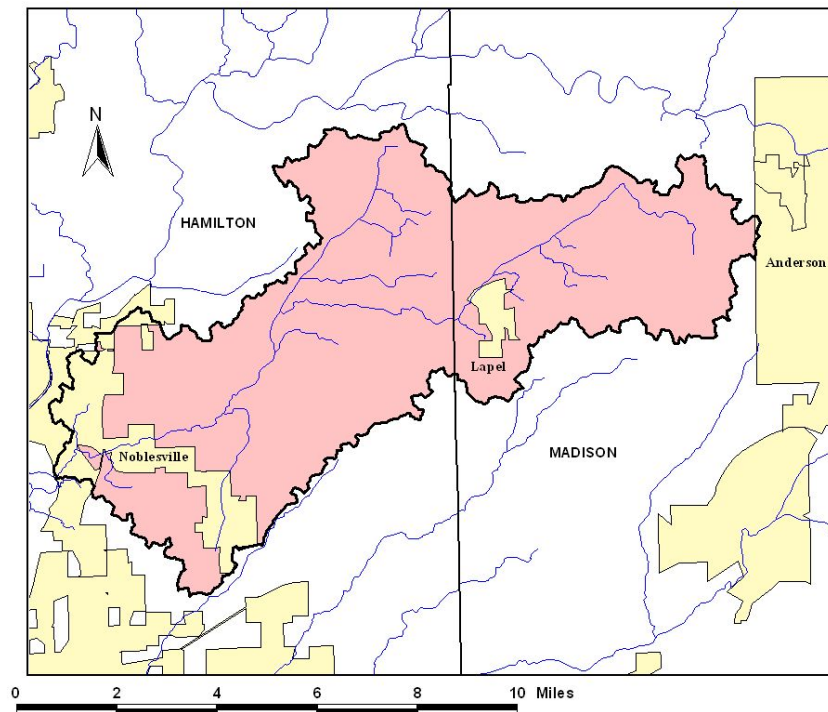


Figure 2-4. Spatial Extent of the Stony Creek Watershed, with Associated Communities.

2.1 **POPULATION**

Recent population changes within the four watersheds can be gauged by reviewing 1990 and 2000 census data for the ten municipalities that are completely or partially contained within the watersheds. Table 2-1 shows the changes in population that occurred in the ten municipalities during that time period. With the exceptions of Orestes and Muncie, all of the municipalities experienced growth over the ten years. Of particular note is the 62% growth that occurred in the city of Noblesville during that period. That growth is consistent with the rate for the rest of Hamilton County, which is one of the fastest growing counties in the country.

City	County	1990 Population	2000 Population	% Change
Alexandria	Madison	5,709	6,260	9.7%
Anderson	Madison	59,459	59,734	0.5%
Elwood	Madison	9,494	9,737	2.6%
Frankton	Madison	1,736	1,905	9.7%
Gaston	Delaware	979	1,010	3.2%
Lapel	Madison	1,742	1,855	6.5%
Muncie	Delaware	71,035	67,430	-5.1%
Noblesville	Hamilton	17,655	28,590	61.9%
Orestes	Madison	458	334	-27.1%
Summitville	Madison	1,010	1,090	7.9%

Table 2-1. Comparison of 1990 and 2000 Census Population Data for 10 Communities within the Four Watersheds (US Census Bureau, 2000)

2.2 TOPOGRAPHY

Multiple sources of elevation data were considered for use in this project. Ultimately, the Shuttle Radar Topography Mission dataset or SRTM (NASA, 2002) was selected for use in delineating the watersheds. This data was acquired from the USGS National Map Seamless Data Distribution System (<http://seamless.usgs.gov>) and is provided as unprojected grid data in decimal degrees and referenced to the World Geodetic System of 1984 (WGS84) horizontal datum. Elevation values are provided in meters. The SRTM dataset was acquired at a scale of one elevation value for each arc-second of latitude and longitude. For central Indiana, this corresponds to one elevation value for every 23.6 meters of latitudinal distance and one value for every 30.9 meters of longitudinal distance.

The SRTM was projected to the UTM-NAD27 map projection with a grid cell size of 30 meters. The resultant grid was then converted to vertical units of feet. Figure 2-5 shows the entire SRTM dataset for the study area encompassing the four watersheds.

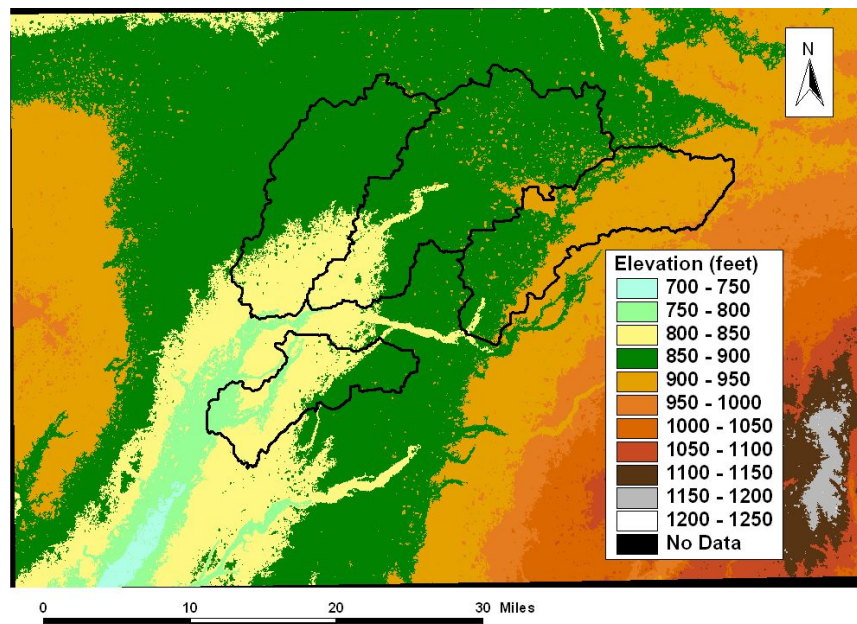


Figure 2-5. Shuttle Radar Topography Mission (SRTM) Elevations for the Duck, Pipe, Killbuck, and Stony Creek TMDL Study Area

Figure 2-6 shows the SRTM elevations for the Duck Creek watershed, as defined by the SRTM delineation. Elevations in the Duck Creek watershed range from 790 feet at the confluence with the West Fork White River to 936 feet in the headwaters. Average slope in the watershed (calculated as the average of slopes in all 30 meter x 30 meter grid cells) is 2.9 percent.

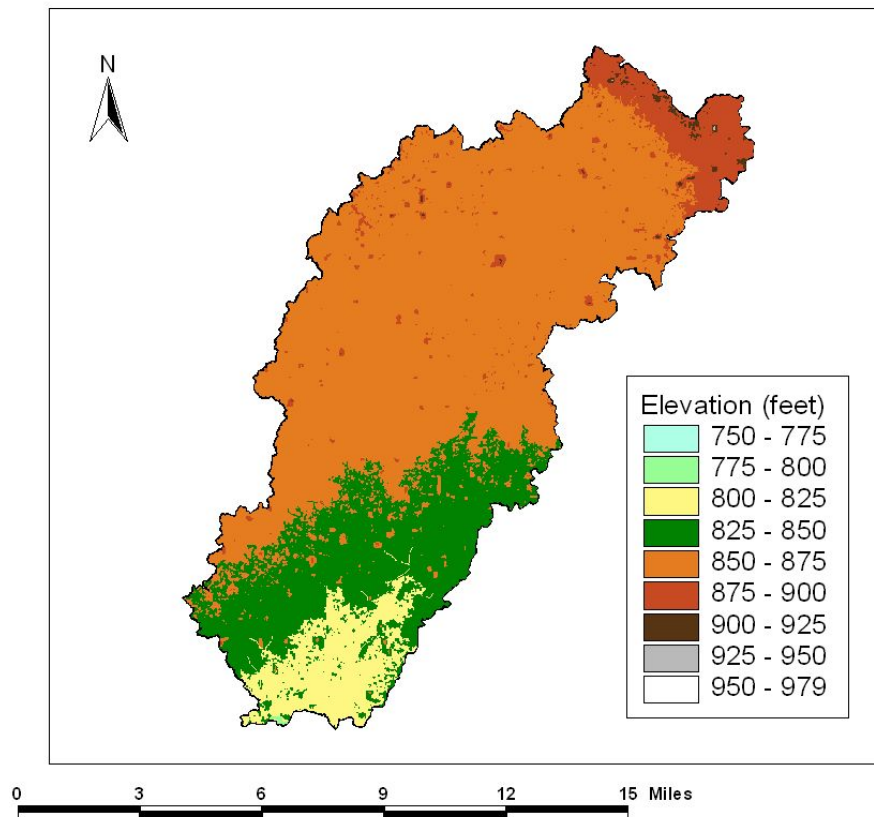


Figure 2-6. SRTM Elevations for the Duck Creek watershed

The Pipe Creek watershed SRTM elevations are shown in Figure 2-7. Elevations range between 795 feet at the confluence with the West Fork White River to 947 feet in the headwaters. Average slope in the Pipe Creek watershed is 3.4 percent.

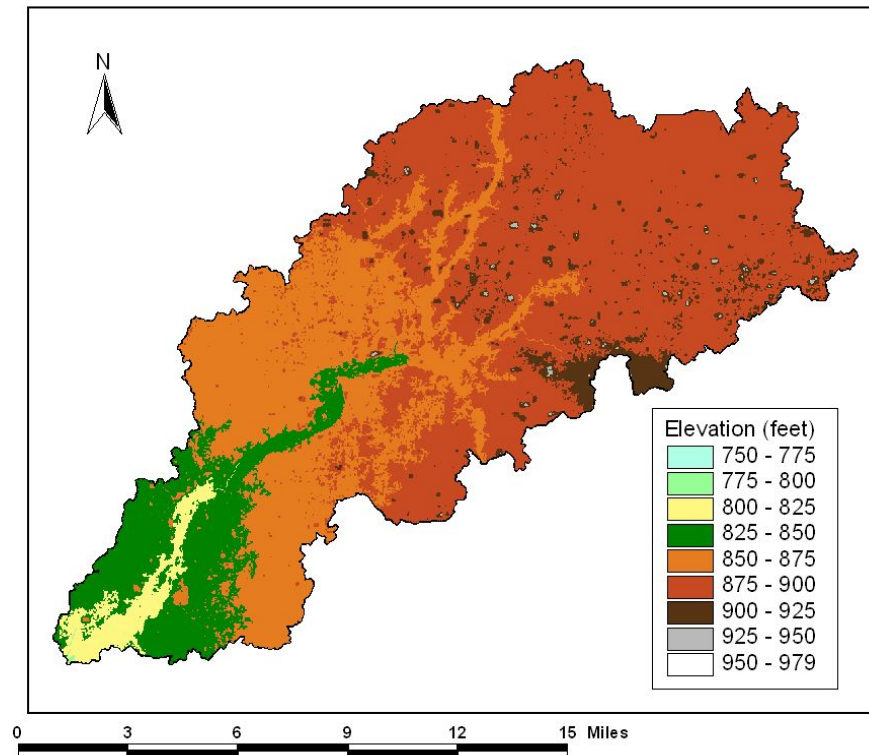


Figure 2-7. SRTM Elevations for the Pipe Creek watershed

The Killbuck Creek watershed SRTM elevation distributions are presented in Figure 2-8. The high point of the watershed, in the headwaters near Muncie is 979 feet and elevation at the outlet to the West Fork White River is 846 feet. The average slope in the Killbuck Creek watershed is 3.9 percent.

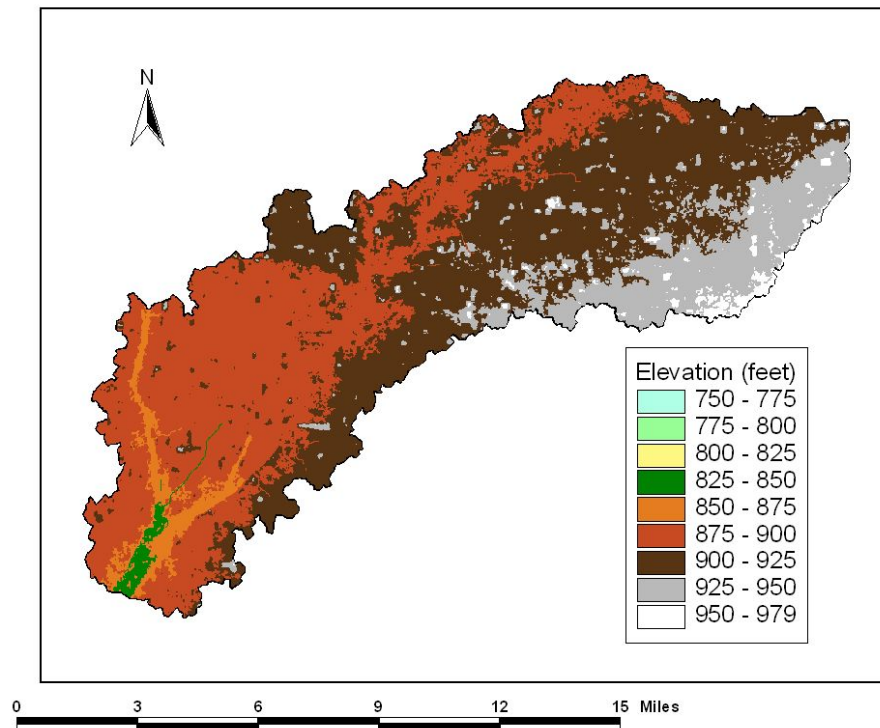


Figure 2-8. SRTM Elevations for the Killbuck Creek watershed

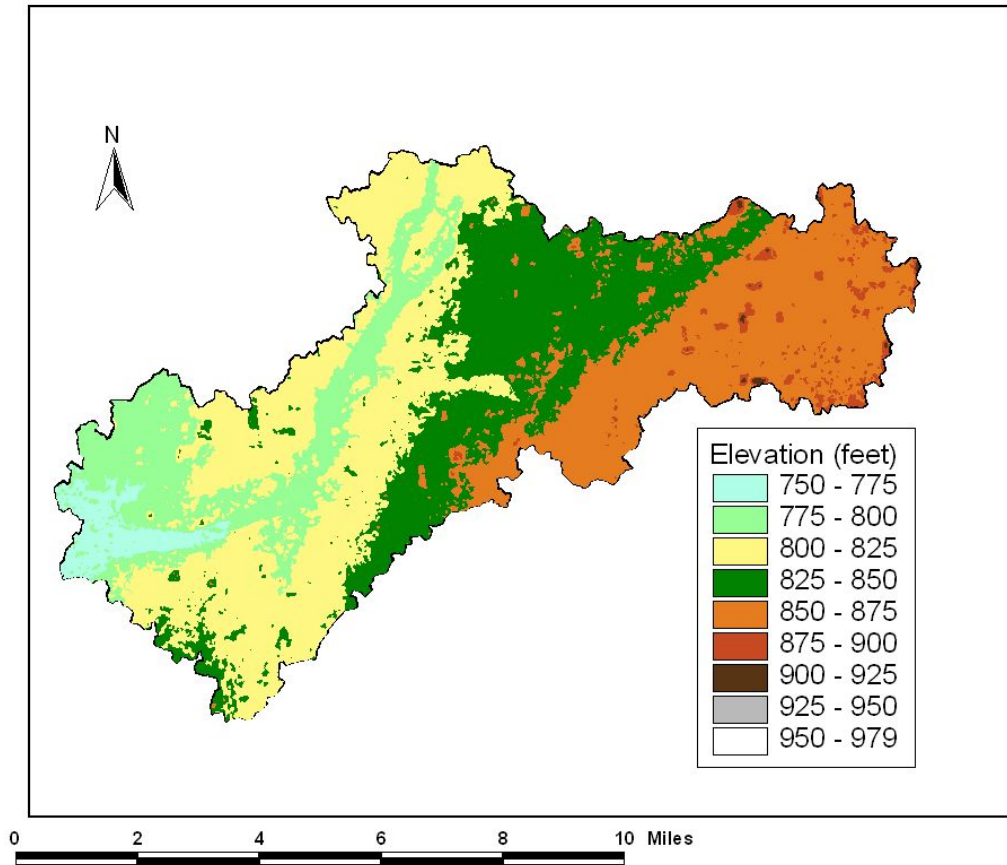


Figure 2-9. SRTM Elevations for the Stony Creek watershed

2.3 LAND USE

The National Land Cover Dataset, or NLCD (USGS, 1999) provides the source for the land use/land cover layer used for this project. The NLCD was acquired from the Indiana Geological Survey website. The NLCD was cooperatively produced by the USGS and the USEPA to maintain a consistent, land cover data layer for the United States, based on 30-meter Landsat thematic mapper (TM) data. The TM data used for creation of the NLCD was acquired by the Multi-Resolution Land Characterization (MRLC) Consortium, which includes the USGS, USEPA, the U.S. Forest Service (USFS), and the National Oceanic and Atmospheric Administration (NOAA). This Indiana data layer was updated in 1999 and nominally includes land cover classifications as observed in 1992. The NLCD is provided in grid format with one land use classification value for each 30 meter x 30 meter parcel of land, and is projected in an Albers Conical Equal Area projection referencing the NAD83 datum.

The NLCD grid was converted to a polygon shapefile, and then reprojected to the UTM NAD27 map projection. Figures 2-10 through 2-13 show the resultant land use coverages, as clipped to the SRTM-delineated boundaries for each watershed. As can be seen from the figures, each watershed is dominated by agricultural row crop classifications. Table 2- 2 shows the percentile breakdown of NLCD categories in each of the four watersheds. The row crops and pasture land acreage, when considered together, make up over 90% of the land coverage in three of the four watersheds (Duck, Pipe, and Stony Creek). The sum of row crop and pasture land acreage in the Killbuck Creek watershed is approximately 81%.

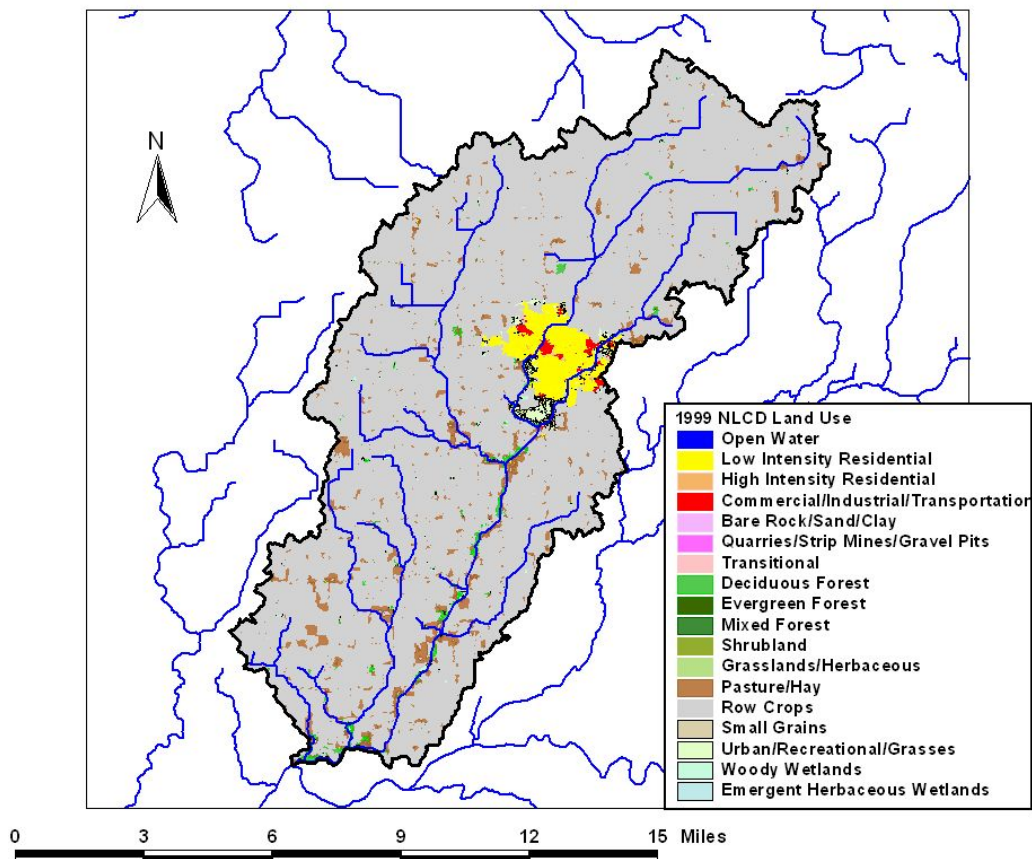


Figure 2-10. NLCD Land Cover Classifications for the Duck Creek Watershed

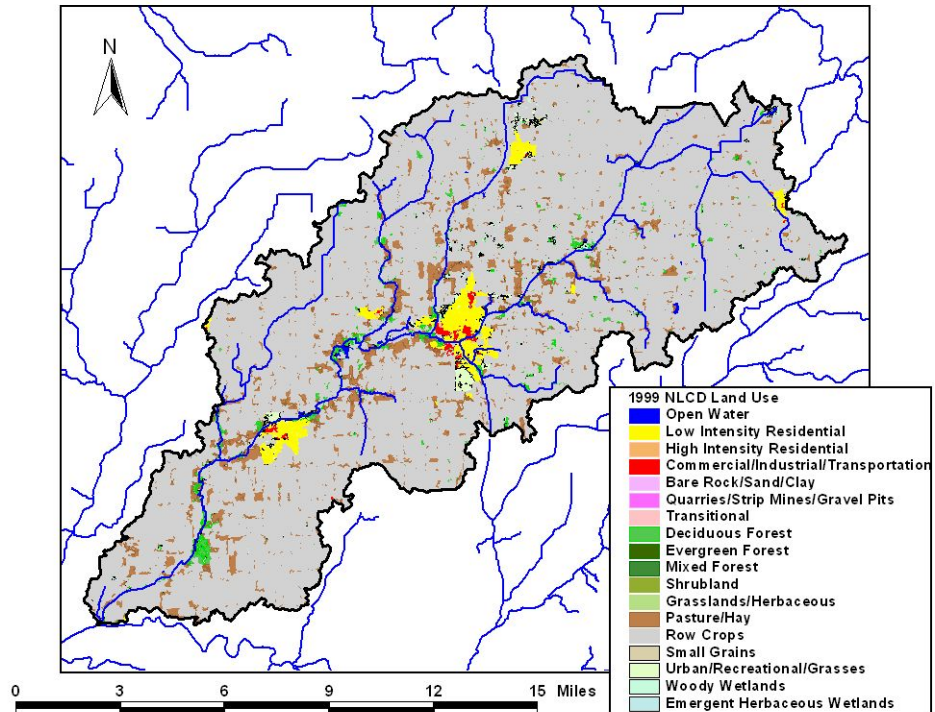


Figure 2-11. NLCD Land Cover Classifications for the Pipe Creek Watershed

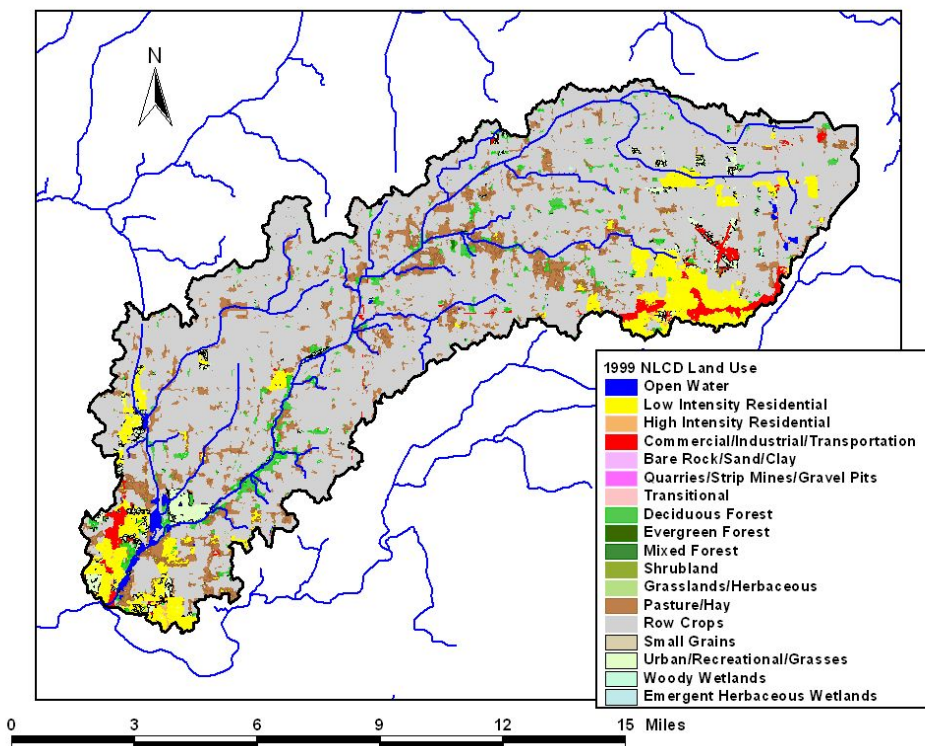


Figure 2-12. NLCD Land Cover Classifications for the Killbuck Creek Watershed

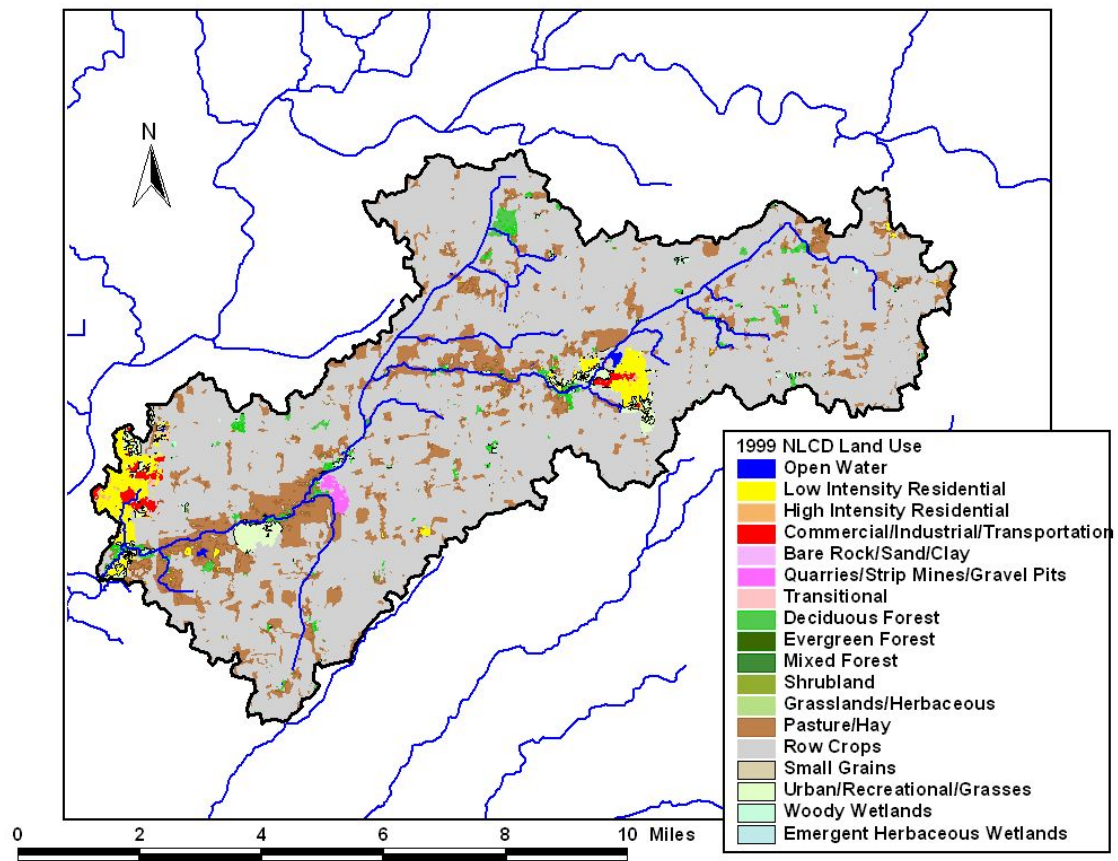


Figure 2-13. NLCD Land Cover Classifications for the Stony Creek Watershed

Table 2-2. Land Use Distributions in the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek Watersheds (NLCD)

NLCD Land Use Category (MRLC Classifications)	Duck Creek		Pipe Creek		Killbuck Creek		Stony Creek	
	Area (acres)	Percent	Area (acres)	Percent	Area (acres)	Percent	Area (acres)	Percent
Open Water	8	0.01%	192	0.2%	349	0.5%	47	0.1%
Low Intensity Residential	1,715	2.6%	2,254	2.3%	4,490	6.7%	855	2.4%
High Intensity Residential	138	0.2%	131	0.1%	343	0.5%	103	0.3%
Commercial/Industrial/Transportation	287	0.4%	432	0.4%	1,263	1.9%	234	0.7%
Quarries/Strip Mines/Gravel Pits	0.0	0.0%	0.0	0.0%	0.0	0.0%	109	0.3%
Deciduous Forest	1,045	1.6%	2,829	2.8%	3,404	5.1%	931	2.6%
Evergreen Forest	0.7	0.001%	3	0.003%	17	0.03%	0.7	0.002%
Mixed Forest	0.7	0.001%	1	0.001%	2	0.003%	0.4	0.001%
Pasture/Hay	5,499	8.4%	11,679	11.7%	9,564	14.4%	6,242	17.5%
Row Crops	55,399	84.7%	79,413	79.8%	44,506	66.8%	26,092	73.3%
Urban/Recreational/Grasses	623	1.0%	1,051	1.1%	2,140	3.2%	666	1.9%
Woody Wetlands	718	1.1%	1,456	1.5%	483	0.7%	296	0.8%
Emergent Herbaceous Wetlands	8	0.01%	62	0.1%	45	0.1%	7	0.02%
Totals	65,442	100.0%	99,503	100.0%	66,605	100.0%	35,583	100.0%

2.4 SOILS

Soils data are commonly available from the US Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS) in two formats: the 1:250,000-scale State Soil Geographic (STATSGO) database, and the 1:24,000-scale Soil Survey Geographic (SSURGO) database. While the SSURGO database would be the preferred soils data layer for this project, the SSURGO data layer for Madison County is not yet available for public distribution. For this reason, the STATSGO database (USDA-NRCS, 2002) was selected to characterize the soils distribution in each of the four watersheds. The STATSGO layer for Indiana was acquired from the IGS website and reprojected to UTM – NAD27.

The attributes of interest in the STATSGO soils layer are the hydrologic soil group and the drainage classification. From the hydrologic soil group perspective, the soils in each of the four watersheds are quite similar, with the upper watershed areas having class C soils with slow infiltration rates. In the lower watershed riparian zones, soils generally become better drained with the moderate infiltration rates associated with hydrologic soil group B. The Duck Creek watershed also has some upper watershed areas classified as class B/D, which are typically poorly drained soils that can be managed to improve infiltration to moderate rates. Figures 2-14 through 2-17 show the STATSGO Hydrologic Soil Groups for all four watersheds.

Drainage Classification is the other STATSGO attribute of interest for this project. Drainage classification will be used along with the NLCD row crop category to identify probable tile drained parcels. Figures 2-18 through 2-21 show the STATSGO Drainage Classifications for all four watersheds.

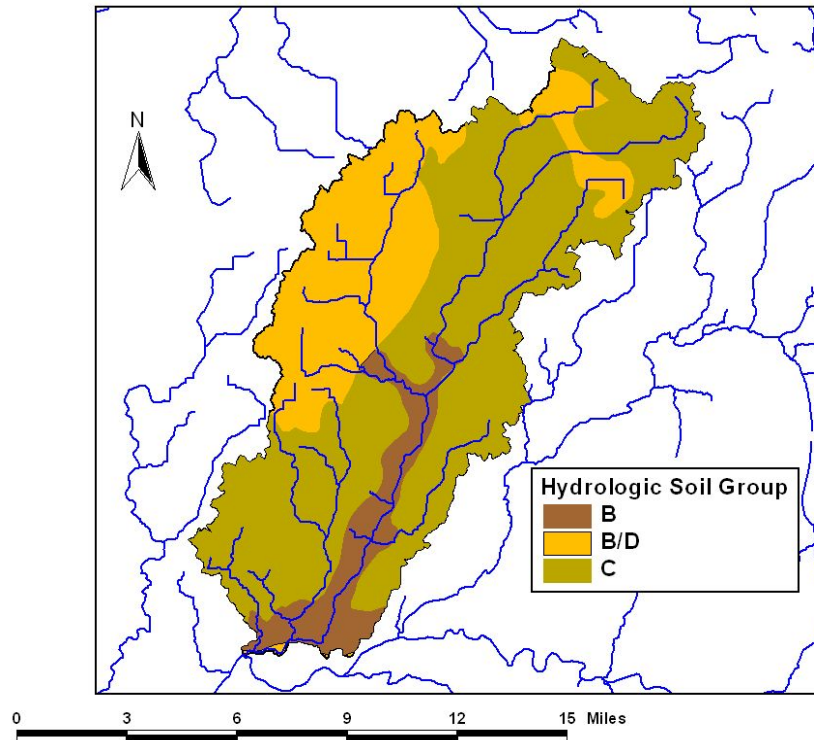


Figure 2-14. STATSGO Hydrologic Soil Group Categories for the Duck Creek Watershed

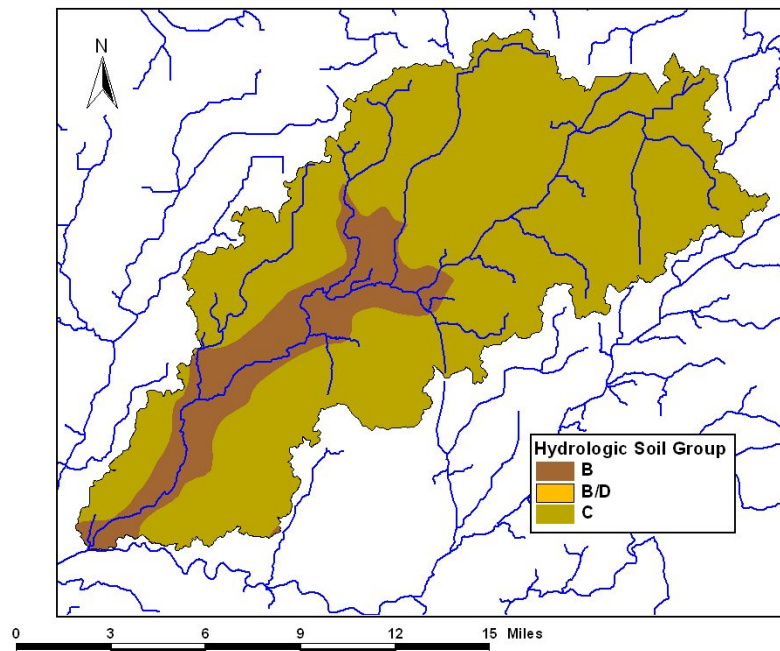


Figure 2-15. STATSGO Hydrologic Soil Group Categories for the Pipe Creek Watershed

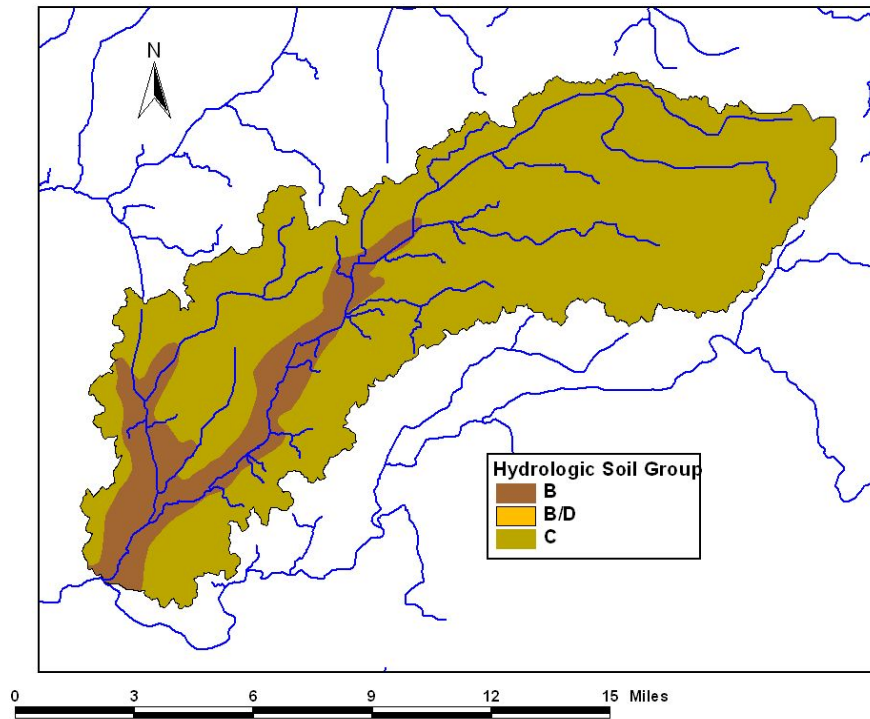


Figure 2-16. STATSGO Hydrologic Soil Group Categories for the Killbuck Creek Watershed

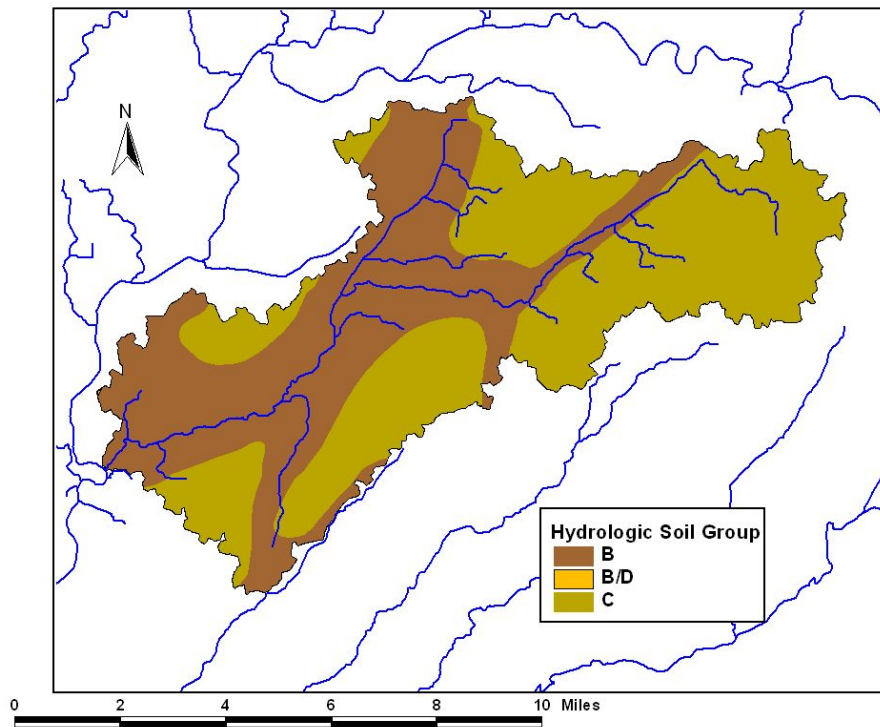


Figure 2-17. STATSGO Hydrologic Soil Group Categories for the Stony Creek Watershed

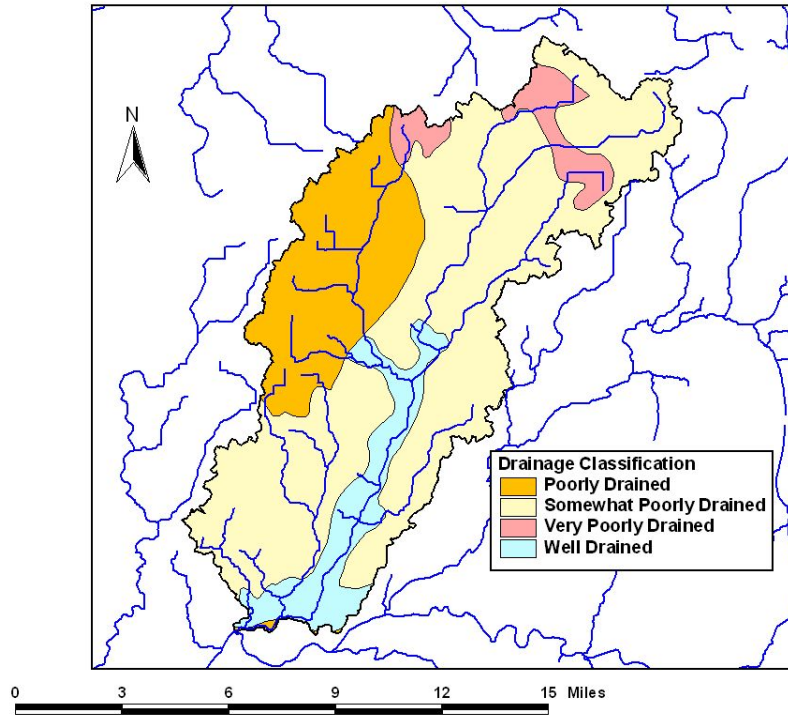


Figure 2-18. STATSGO Drainage Classification Categories for the Duck Creek Watershed

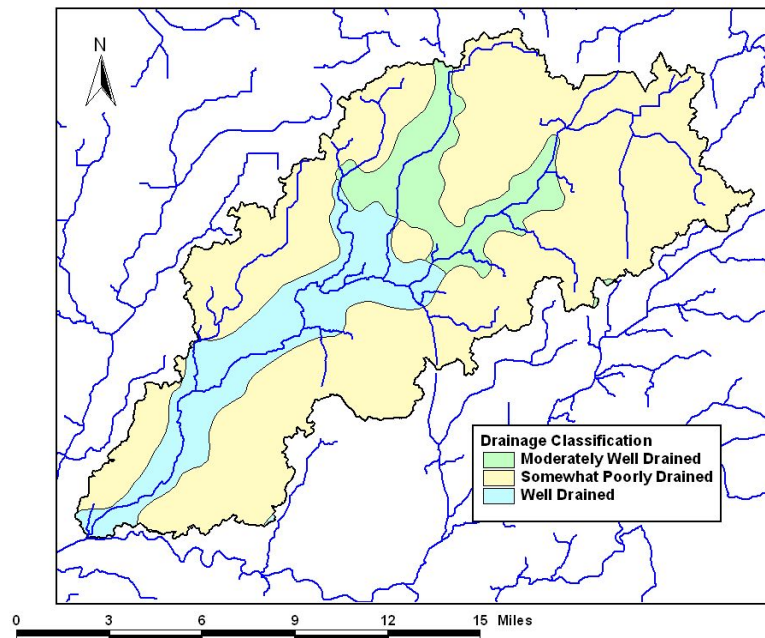


Figure 2-19. STATSGO Drainage Classification Categories for the Pipe Creek Watershed

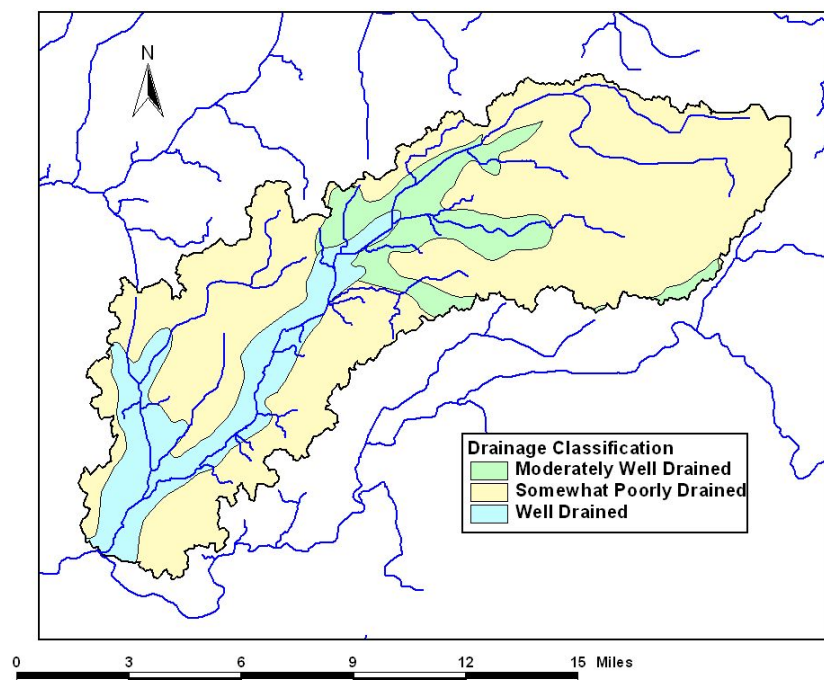


Figure 2-20. STATSGO Drainage Classification Categories for the Killbuck Creek Watershed

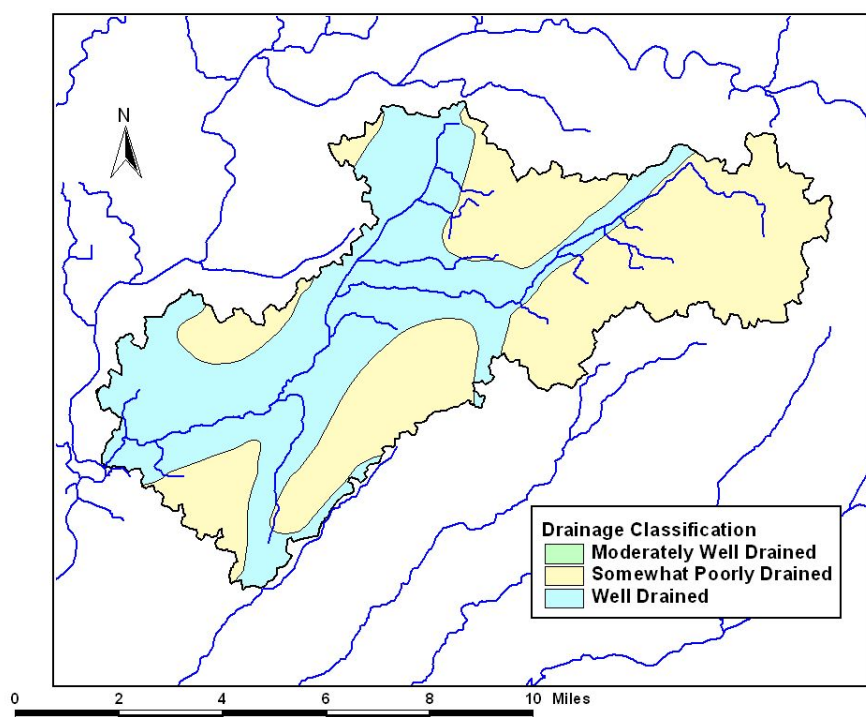


Figure 2-21. STATSGO Drainage Classification Categories for the Stony Creek Watershed

2.5 ROW CROP PATTERNS

Annual crop distributions are available from the U.S. Department of Agriculture National Agricultural Statistics Service (USDA-NASS, 2003). For this project, grid files of the row crop distributions for the years 2000 – 2002 were acquired from the Purdue University Agricultural and Biological Engineering Department. This data was valuable in identifying specific crop locations where tile drainage is also probable due to soil characteristics. The row crop distributions are projected in the UTM – NAD83 map projection. Non-row crop land coverage (e.g. urban, open water, wetland, forest land) are also noted in the layers. Figures 2-22 through 2-25 show the 2001 row crop distributions for all four watersheds. These figures show that corn and soybeans were the predominant crops in all four watersheds during 2001.

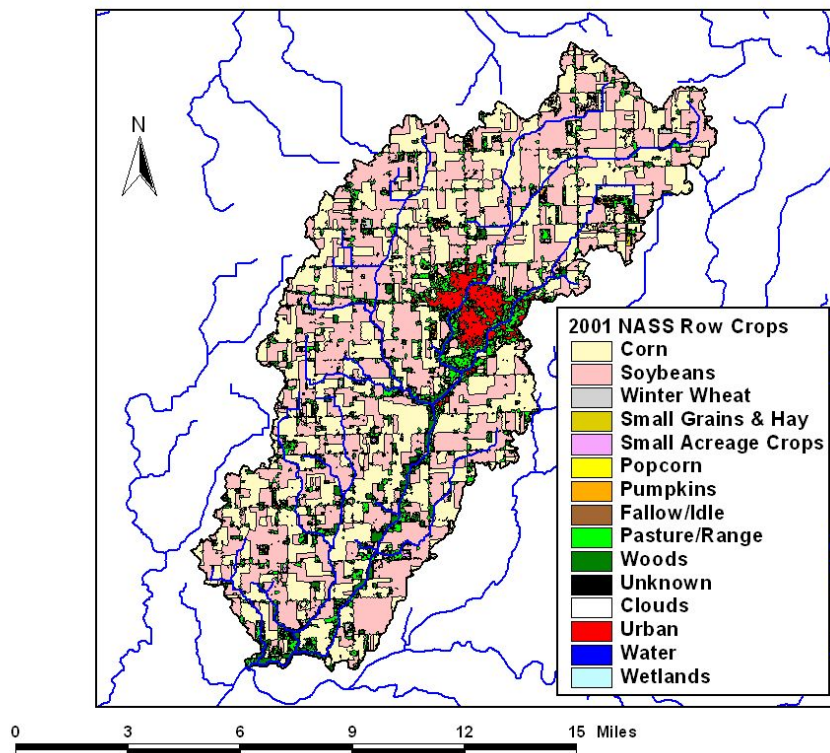


Figure 2-22. 2001 NASS Row Crop Distributions for the Duck Creek Watershed

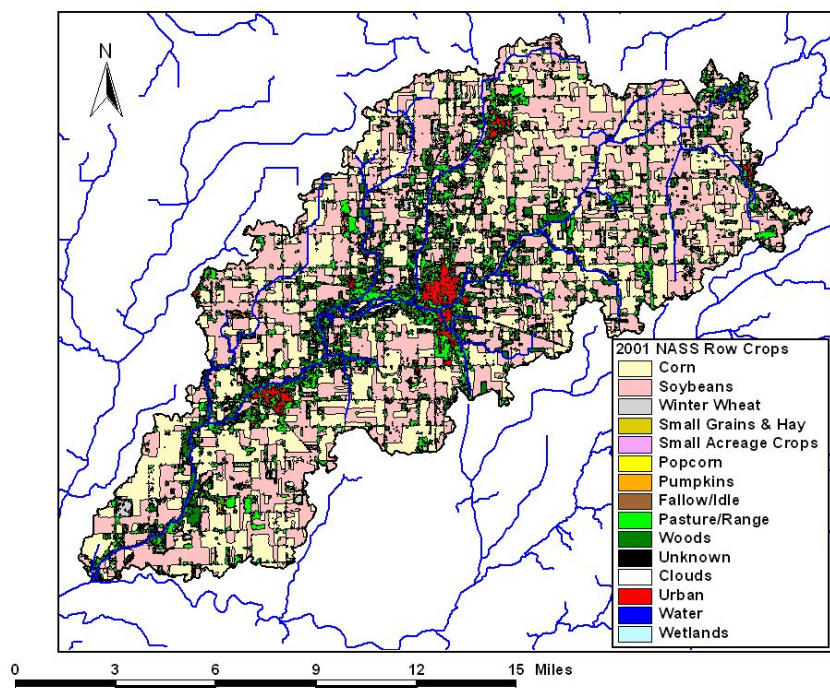


Figure 2-23. 2001 NASS Row Crop Distributions for the Pipe Creek Watershed

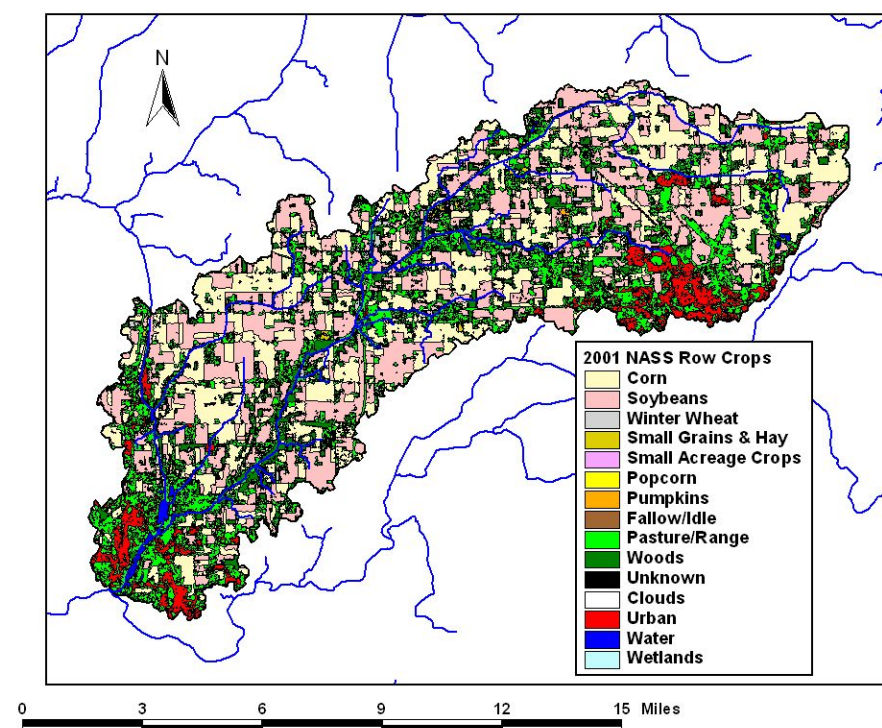


Figure 2-24. 2001 NASS Row Crop Distributions for the Killbuck Creek Watershed

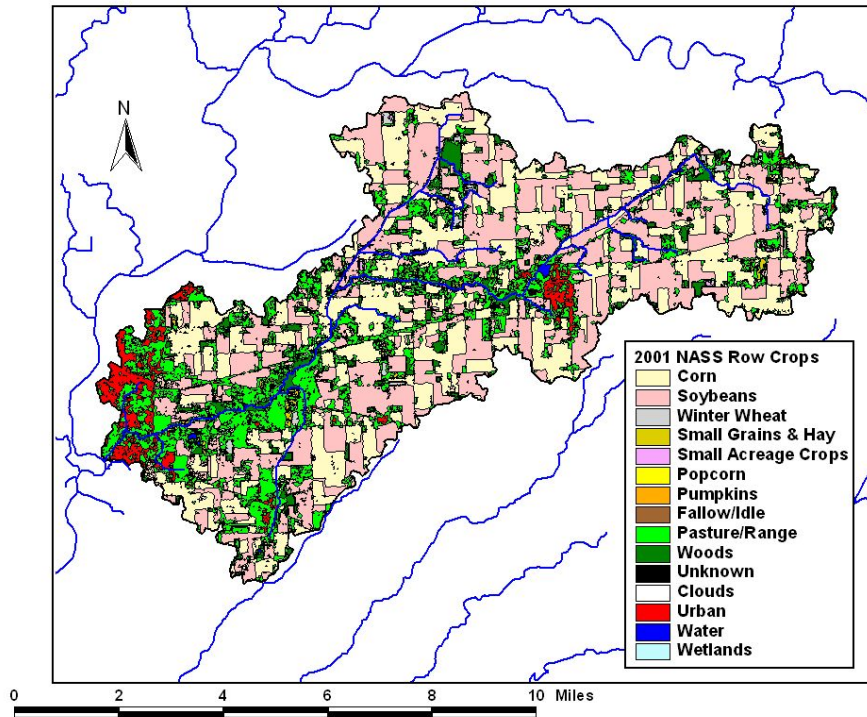


Figure 2-25. 2001 NASS Row Crop Distributions for the Stony Creek Watershed

2.6 PRECIPITATION

Three National Climatic Data Center (NCDC) gages are located near the study watersheds and provide temperature and precipitation data (NCDC, 2004). These are Farmland 5 (IN2825), the gage at Anderson STP (IN0177) and Tipton 5 SW (IN8784). Additional precipitation data have been collected in the Killbuck Creek watershed during 2002-2004 as a component of the West Fork White River Watershed Project (Delaware County SWCD, 2002-2004).

The majority of IDEM's water quality samples were collected during the summer of 2001, so monthly precipitation data for 2001 was examined for each of the three stations. Figure 2-26 presents a comparison of this data for all three stations.

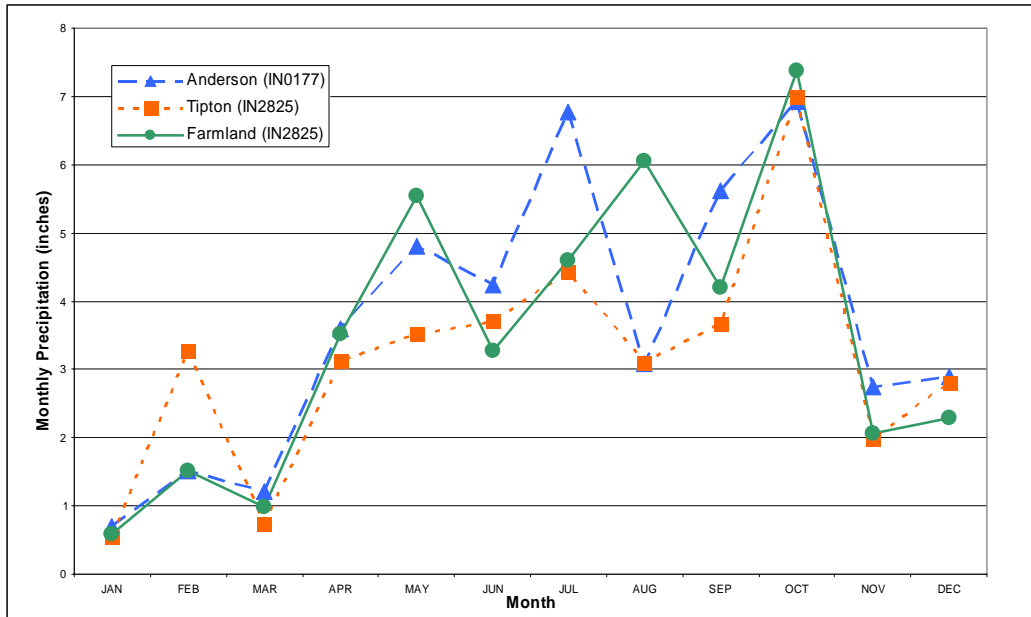


Figure 2-26. Monthly Precipitation in 2001 at Three NCDC Gages near Subject Watersheds

Precipitation data collected during the water quality assessment period show that from 1994-early 2004, the average annual precipitation in the study watersheds was 38.3 inches with a maximum annual precipitation of 50.7 inches and a minimum of 29.1 inches. Figure 2-27 shows the annual precipitation at these stations from the beginning of the assessment period to the present.

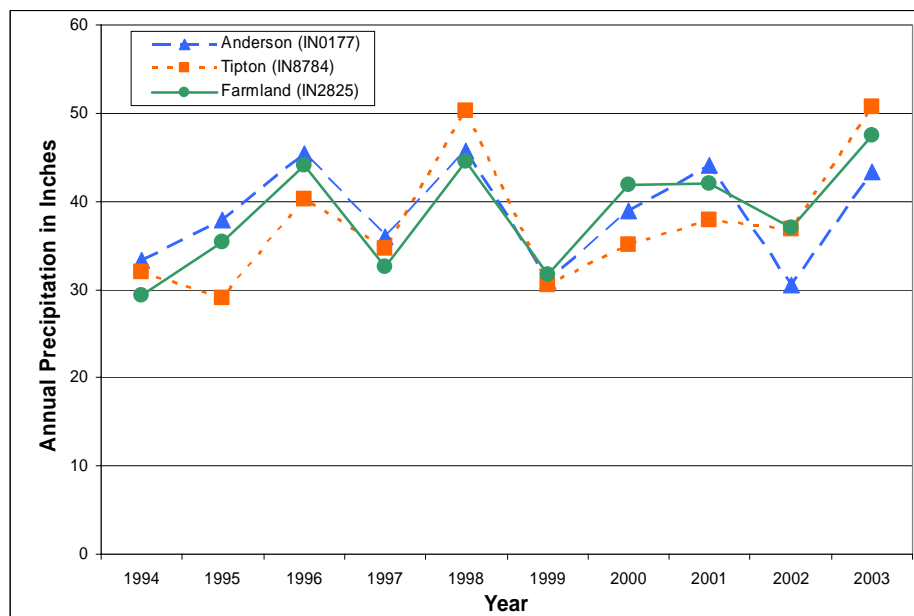


Figure 2-27. Annual Precipitation at Three NCDC Gages near Subject Watersheds

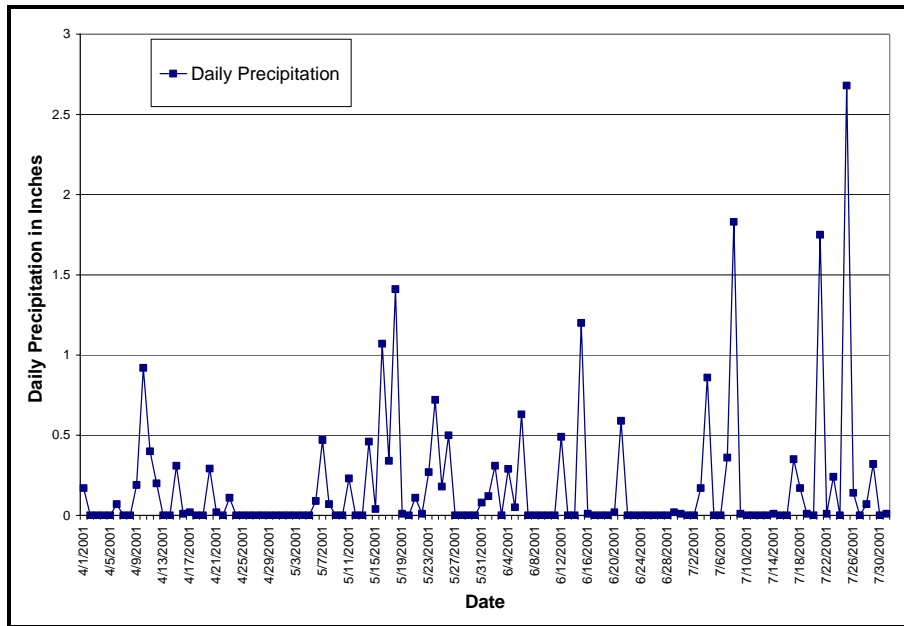


Figure 2-28. Daily Precipitation Values at Muncie Municipal Airport during the Water Quality Assessment Period of April – July 2001.

Additionally, daily precipitation values for the nearest station, Muncie Municipal Airport, were obtained for the water quality assessment period from April – July 2001. These values are presented in Figure 2-28 (NCDC, 2005).

2.7 HYDROGRAPHY

The USGS 1:100,000 scale National Hydrography Dataset, or NHD (USGS, 2002) was selected to represent the stream network in the four watersheds. The NHD was constructed as a cooperative effort between the USGS and the EPA to combine the respective attributes of the earlier USGS Digital Line Graph (DLG) layer and the EPA's River Reach File 3 (RF3). The NHD was acquired from the Indiana Geological Survey (IGS) website (<http://igs.indiana.edu>), reprojected to UTM – NAD27, and clipped to the extent of the SRTM-delineated watersheds. In order to facilitate accurate delineation of watershed boundaries in flat areas, it is imperative that upper watershed (i.e. first order) streams in the delineated and adjacent watersheds are included in the hydrography layer. Upon inspection of the NHD for the four watersheds, it was apparent that some of these upper watershed canals and ditches were not included. For those cases, the missing first order streams were manually extracted from digital raster graphic (DRG) quadrangle maps of the study area (USGS, 1996) and added into the hydrography layer. Figures 2-29 through 2-32 show the NHD data layers for each watershed. Upper watershed streams that were extracted from the DRG maps are also identified in the figures.

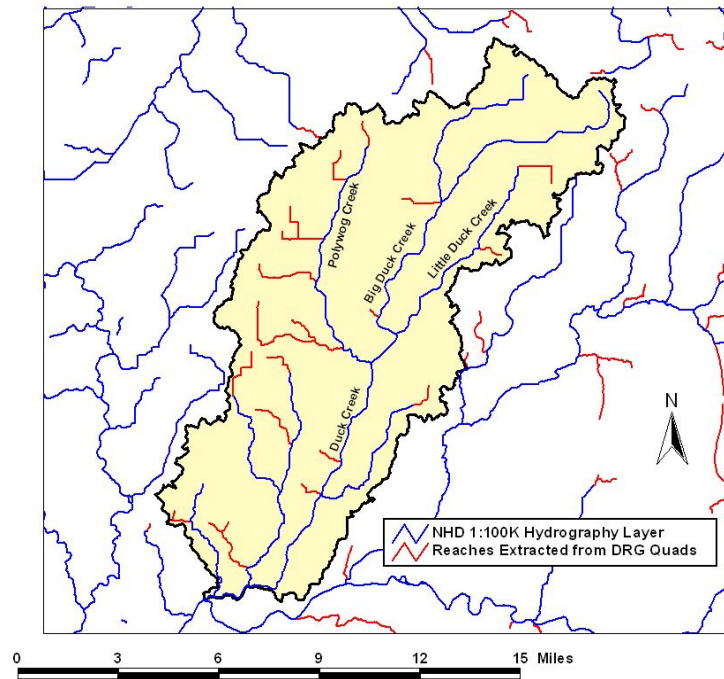


Figure 2-29. NHD Appended Hydrography for the Duck Creek Watershed

Figure 2-30. NHD Appended Hydrography for the Pipe Creek Watershed

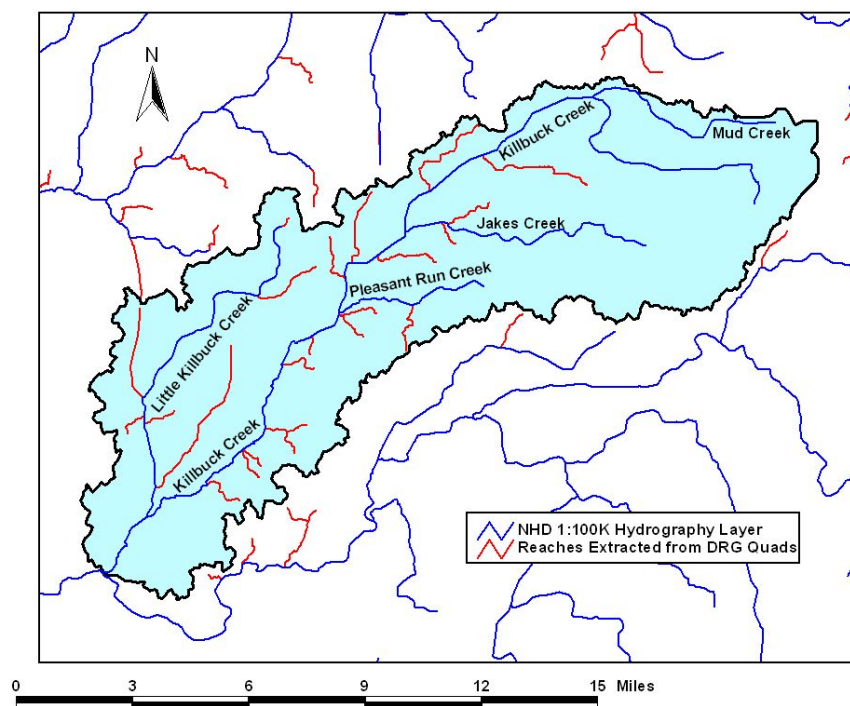
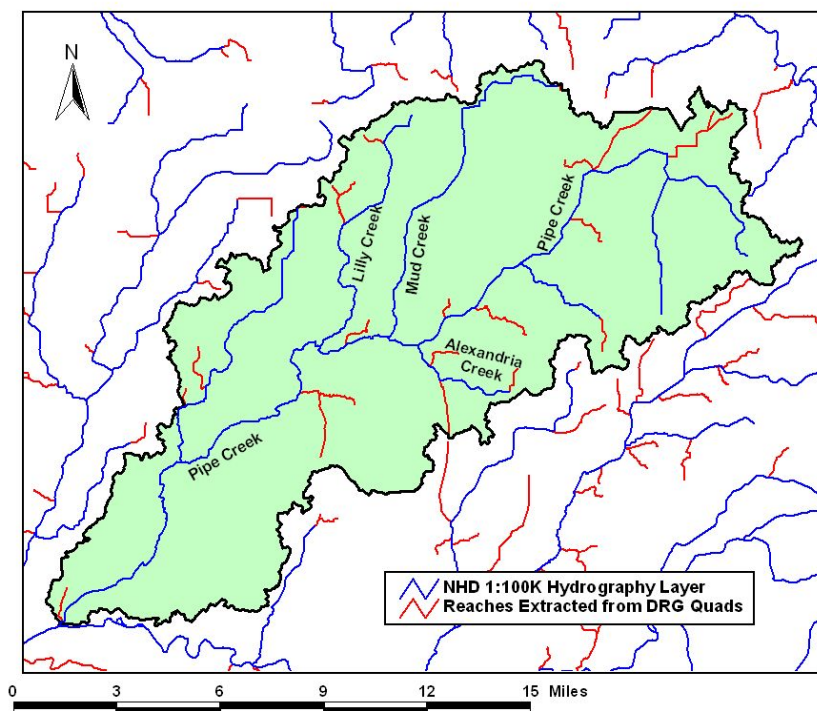


Figure 2-31. NHD Appended Hydrography for the Killbuck Creek Watershed

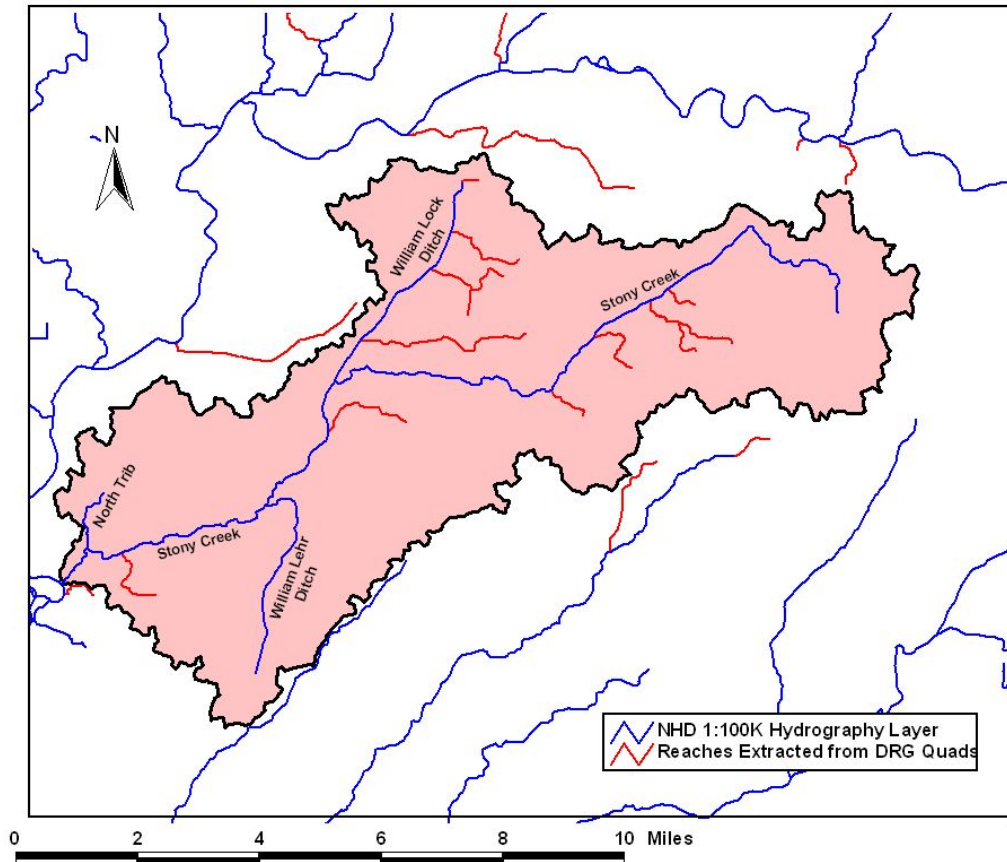


Figure 2-32. NHD Appended Hydrography for the Stony Creek Watershed

2.8 HYDROLOGY

Of the four watersheds that are the focus of this study, Pipe Creek and Stony Creek have USGS stream gages that were active at the time of water quality sampling. Additional flow data were provided by the Upper White River Watershed Project. Killbuck Creek discharge was calculated by measuring the water depth and stream velocity for several stream subsections. This data set contains two years of flow data. Because no flow data exist for the Duck Creek watershed (Arvin, 2004), surrogate flows were established by utilizing data from the Pipe Creek flow gage. This flow was adjusted by utilizing a “drainage area ratio” approach, which considers the drainage areas for respective subwatersheds contributing flow to ungaged locations (Stedinger, et al., 1993). The resultant estimated flow record will be sufficient for constructing a load duration curve. Figure 2-33 illustrates the locations of the three flow gages that were utilized in this study.

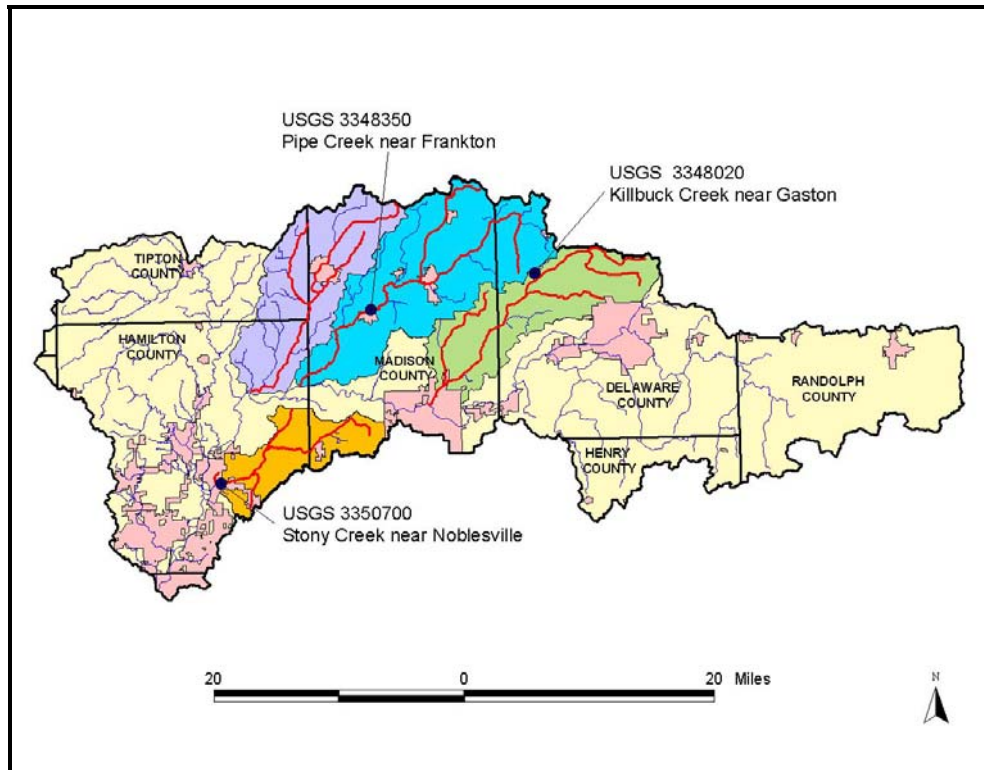


Figure 2-33. USGS Flow Stations in the Study Area

3.0 INVENTORY AND ASSESSMENT OF WATER QUALITY INFORMATION

The Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek watersheds are listed as impaired on Indiana's 2004 303(d) List for violations of the State's water quality standard for *E. coli* bacteria.

IDEM has sampled water quality data for a total of 56 stations in the four watersheds. Depending on the watershed, the data covers a period of 1996-2004, including the 1998, 2001, and 2004 assessments completed in support of IDEM's 303(d) listing and TMDL development. Figure 3-1 presents the locations of the impairments and surface water quality stations in each watershed.

In addition to IDEM water quality monitoring sites, additional sites were monitored by watershed groups in the Killbuck Creek and Stony Creek watersheds. Six stations in the upper portion of Killbuck Creek were monitored as part of the Upper White River Watershed Project under the direction of the Delaware County Soil and Water Conservation District (2002-2004). The stations were sampled from 2002-2004 and analyzed by the Bureau of Water Quality. Data available to date are included in the Killbuck Creek *E. coli* dataset provided in Appendix A. These data were used to evaluate and confirm recent impairment in the Killbuck watershed for the subwatersheds containing the Upper White River Watershed Project stations.

In the Stony Creek watershed, an assessment was recently completed by Hamilton County in support of the Stony Creek Watershed Master Plan (Baker and Nelson, 2004). This study included an analysis of fecal coliform counts at nine stations throughout the watershed. These counts have been translated to *E. coli* counts, using a multiplication factor of 0.9, to enable comparisons and evaluations with other available data. The translation factor was derived from comparisons of *E. coli* and fecal coliform laboratory analyses from single grab samples at the same source (Drapcho, et al. (2001), Ormsbee and McAlister (2003)). The Stony Creek Watershed Master Plan data provide evidence of more recent water quality violations during 2003, supporting a lack of improvement in the Stony Creek watershed.

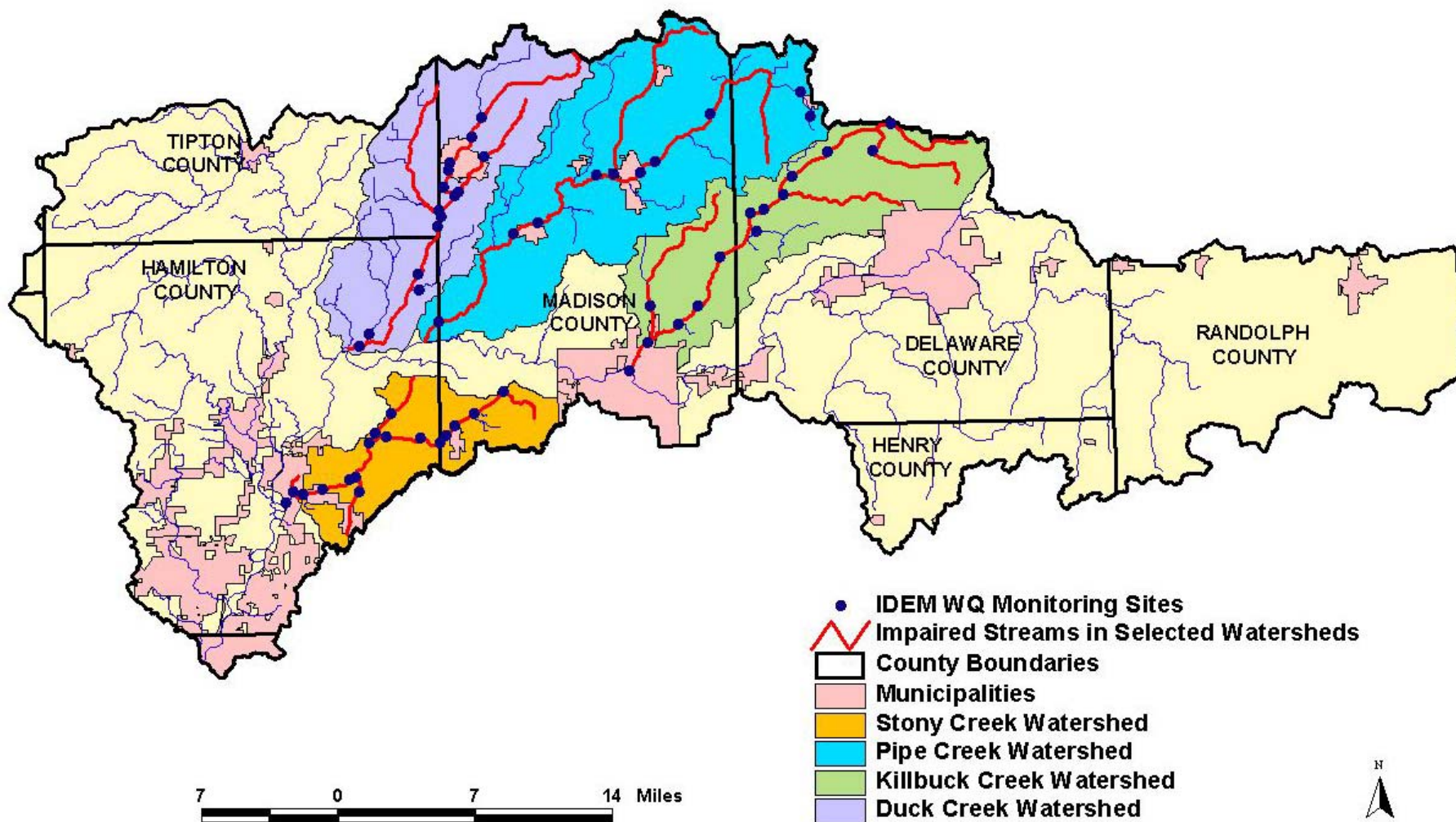


Figure 3-1. Locations of Impairments and IDEM Water Quality Monitoring Sites

3.1 EVALUATION OF DATA USING THE GEOMETRIC MEAN STANDARD

The geometric mean standard applies to all samples collected from April 1 through October 31, which is defined as the recreational season in Indiana's water quality standards. The numeric geometric mean standard for *E. coli* states that, based on five samples collected over a thirty-day period, the geometric mean of *E. coli* counts shall not exceed 125 colonies per 100 milliliters. Although not all historical data sets contain data samples at this frequency, the data collected in each of the four watersheds in the spring and summer for the 2001 assessment meet this requirement. At stations where at least five samples were collected over a thirty-day period, the geometric mean was calculated and compared to the 125 cfu/100 ml standard. Violations of the geometric mean standard verify the impairment of all four waterbodies. Figure 3-2 shows the location of the sampling sites.

3.2 EVALUATION OF DATA USING THE SINGLE SAMPLE STANDARD

The single sample standard applies to all grab samples collected from April 1 through October 31, which is defined as the recreational season in Indiana's water quality standards. The numeric criteria for *E. coli* in waters designated for recreational use in Indiana is 235 cfu/100 ml. The data collected in each of the four watersheds in spring and summer 2001 assessment verify violations of the single sample standard. Appendix B includes water quality duration curve plots of the grab samples collected during 2001. Each sample is plotted at the percentile value of the estimated flow at the monitoring location. Figure 3-2 shows the location of the sampling sites.

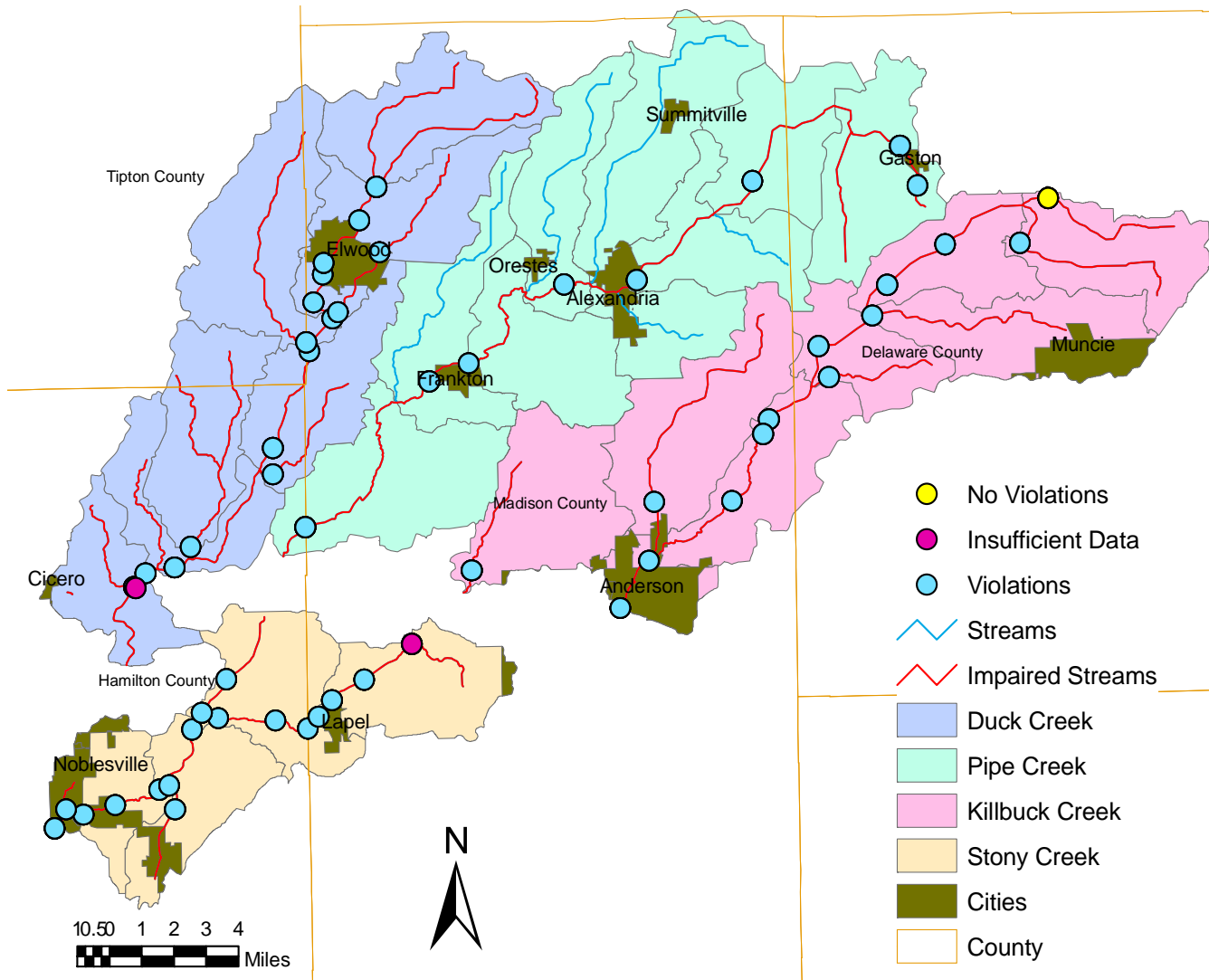


Figure 3-2. Sampling locations and violations of standards at IDEM Water Quality Monitoring Sites

3.3 WATER QUALITY DATA USED IN TMDL APPROACH

The geometric mean *E. coli* counts recorded at each monitoring location were used to calculate the reductions necessary to meet the Indiana geometric mean sample standard for *E. coli*. The TMDL represents the maximum loading that can be assimilated by the waterbody while still achieving the Waters Quality Standard (WQS). As indicated in the Numeric Targets section of this document, the target for this *E. coli* TMDL is 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period and 235 per one hundred milliliters as a single sample maximum from April 1 through October 31. Concurrent with the selection of a numeric concentration endpoint, TMDL development also defines the critical conditions that will be used when defining allowable levels.

For most pollutants, TMDLs are expressed on a mass loading basis (e.g. pounds per day). Also *E. coli* indicators mass is not an appropriate measure because *E. coli* is expressed in terms of organism counts (or resulting concentration) (USEPA, 2001). Meeting the WQS of 125 colony forming unit (cfu) per 100 mL as a geometric mean and 235 cfu/100 mL is the overall goal of the TMDL. The geometric mean *E. coli* WQS allows for the best characterization of the watershed. The geometric mean provides a more reliable measure of *E. coli* concentration because it is less subject to random variation (USEPA, 2004). However, by setting the reduction targets to meet the 125 cfu/100 mL geometric mean standard, this TMDL also will meet the 235 cfu/100 mL single day standard. Therefore, this *E. coli* TMDL is concentration-based consistent with 327 IAC 5-2-11.1(b) and 40 CFR, Section 130.2 (i) and the TMDL is equal to the geometric mean and single sample maximum *E. coli* WQS for the recreational season (April 1 through October 31). The Wasteload Allocation and Load Allocations in the TMDL are set at 125 cfu/mL, geometric mean and 235 cfu/100 mL single day standard. Using the geometric mean also results in a greater reduction than using the single day standard as a target. This will be of value as part of the Margin of Safety.

4.0 SOURCE ASSESSMENT

A source assessment is used to characterize the known and suspected sources of *E. coli* bacteria in an impaired watershed for use in the water quality analysis and the development of TMDLs. Bacteria sources are divided into classes, point (WLA) and nonpoint (LA) sources. This chapter presents the individual source categories within those two classes of sources.

4.1 POINT SOURCES

Point sources are sources through which a discharge passes to a receiving water body via conveyance, such as a pipe, ditch, channel, or conduit. The term “point source” includes wastewater treatment plants (WWTPs), concentrated animal feeding operations (CAFOs), combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), straight pipe discharges from on site septic, and stormwater runoff from municipal storm sewer systems (MS4).

4.1.1 WASTEWATER TREATMENT PLANTS

All National Pollutant Discharge Elimination System (NPDES) permits in the four watersheds were acquired from the IDEM Office of Water Quality. Any NPDES facility having *E. coli* effluent limits includes the respective geometric mean and single sample standards of 125 col/100 mL and 235 col/100 mL as the numeric values for the limits (Table 4-1).

The Duck Creek watershed contains the Elwood Sewage Treatment Plant which is permitted to discharge up to 3.22 MGD. In an Agreed Order between the City of Elwood and IDEM (IDEM, 2002), the City acknowledged that the daily maximum effluent limit for *E. coli* was violated between April and September 2001, a period which coincides with IDEM's 2001 targeted sampling of *E. coli* in the watershed. (Figure 4-1). The Elwood Sewage Treatment Plant has four pretreatment facilities. These pretreatment facilities (Red Giant Foods, Inc., Elas LLC, Centra-Met, Inc., and State Planting LLC) discharge to the Elwood collection system and their waste is treated and discharged from the Elwood Sewage Treatment Plant. The PSI Noblesville Generating Station is located in the watershed but discharges to the West Fork White River. This discharge also does not have a sanitary component so it would not be a source for the TMDL.

The Pipe Creek watershed includes seven municipal discharges, one industrial discharger, and two water treatment plant discharges (Figure 4-2). All eight of the municipal permits have *E. coli* permit limits, the largest of which is the Alexandria Water Pollution Control Plant, which can discharge up to 1.2 MGD. Red Gold is the industrial facility and Alexandria and Gaston are the

water treatment facilities. These facilities do not have permit limits for *E.coli* because none of these effluents contain *E.coli*.

The Killbuck Creek watershed has five municipal discharges and of the four industrial discharges, two fall under general permits (Figure 4-3). Two of the four municipal dischargers have *E.coli* permit limits. The remaining two municipal dischargers have total residual chlorine permits limits. Most municipal facilities that discharge less than 1.0 MGD do not currently have *E. coli* limits, but a total residual chlorine limit instead. Previously, facilities with design flows under 1 MGD (typically minor municipals and semi-publics) were not required to have *E. coli* effluent limits or conduct monitoring for *E. coli* bacteria, provided they maintained specific total residual chlorine levels in the chlorine contact tank. The assumption was that as long as chlorine levels were adequate in the chlorine contact tank, the *E. coli* bacteria would be deactivated and compliance with the *E. coli* WQS would be met by default. The original basis for allowing chlorine contact tank requirements to replace bacteria limits was based on fecal coliform, not *E. coli*. No direct correlation between the total residual chlorine levels and *E. coli* bacteria can be conclusively drawn. Further, it has been shown that exceedances of *E. coli* bacteria limits may still occur when the chlorine contact tank requirements are met. *E. coli* limits will be introduced during each facility's next permit cycle. The four industrial facilities and two general permits do not have permit limits for *E.coli* because none of these effluents contain *E.coli*.

The Stony Creek watershed includes two municipal discharges and three industrial discharges (Figure 4-4). The largest municipal discharge, the Lapel Municipal WWTP, has a maximum permitted flow of 0.36 MGD. Both of the municipal discharges in the Stony Creek watershed have *E. coli* limits. These three industrial facilities do not have permit limits for *E.coli* because none of these effluents contain *E.coli*.

Table 4-1 lists all facilities with *E.coli* limits in each watershed. Figures 4-1 through 4-4 show all permitted facilities and the locations of these facilities within each watershed (IDEM, 2004a).

Table 4-1 NPDES facilities with *E.coli* limits

Watershed	Permit Number	Facility Name	Receiving Stream
Duck Creek	IN0032719	ELWOOD MUNICIPAL STP	West Fork White River Via Big Duck Creek
Pipe Creek	IN0020028	FRANKTON MUNICIPAL WWTP	Pipe Creek
	IN0020044	ALEXANDRIA MUNICIPAL STP	Pipe Creek
	IN0020338	GASTON MUNICIPAL STP	Pipe Creek
	IN0024562	SUMMITVILLE MUNICIPAL WWTP	Illiff Drain to Mud Creek
	IN0031356	PIPE CREEK REST AREA NORTH I69	Richards Ditch to Pipe Creek
	IN0038857	I-69 AUTO TRUCK PLAZA INC.	Yeager Finley Manard Ditch
	IN0060011	KENNEDY MACHINE & TOOL WWTP	Pipe Creek
	ING080128	I-69 AUTO TRUCK PLAZA	Yeager Finley Manard Ditch
Killbuck Creek	IN0025151	WES-DEL JR-SR HIGH SCHOOL	Thurston Ditch to Killbuck Creek
	IN0025402	COUNTRY VILLAGE SUBDIVISION	Killbuck Creek
	IN0053627	RESTING WHEELS MOB. HOME COURT	Drainage tile to Little Killbuck Creek
	IN0054666	BUCKEYE TERMINALS LLC - MUNCIE	Unnamed Ditch to Mudd Creek
	IN0059170	BALL STATE UNIVERSITY - COAL	Eagle Branch Jakes Creek
	IN0061301	MOUNT PLEASANT UTILITIES, LLC	Pleasant Run Creek
	IN0061841	GREENS FORK MUNICIPAL WWTP	Greens Fork
	IN0020087	LAPEL MUNICIPAL WWTP	Stony Creek
	IN0025526	TALL TIMBER MOBILE HOME PARK	Unnamed Tributary to Stony Creek

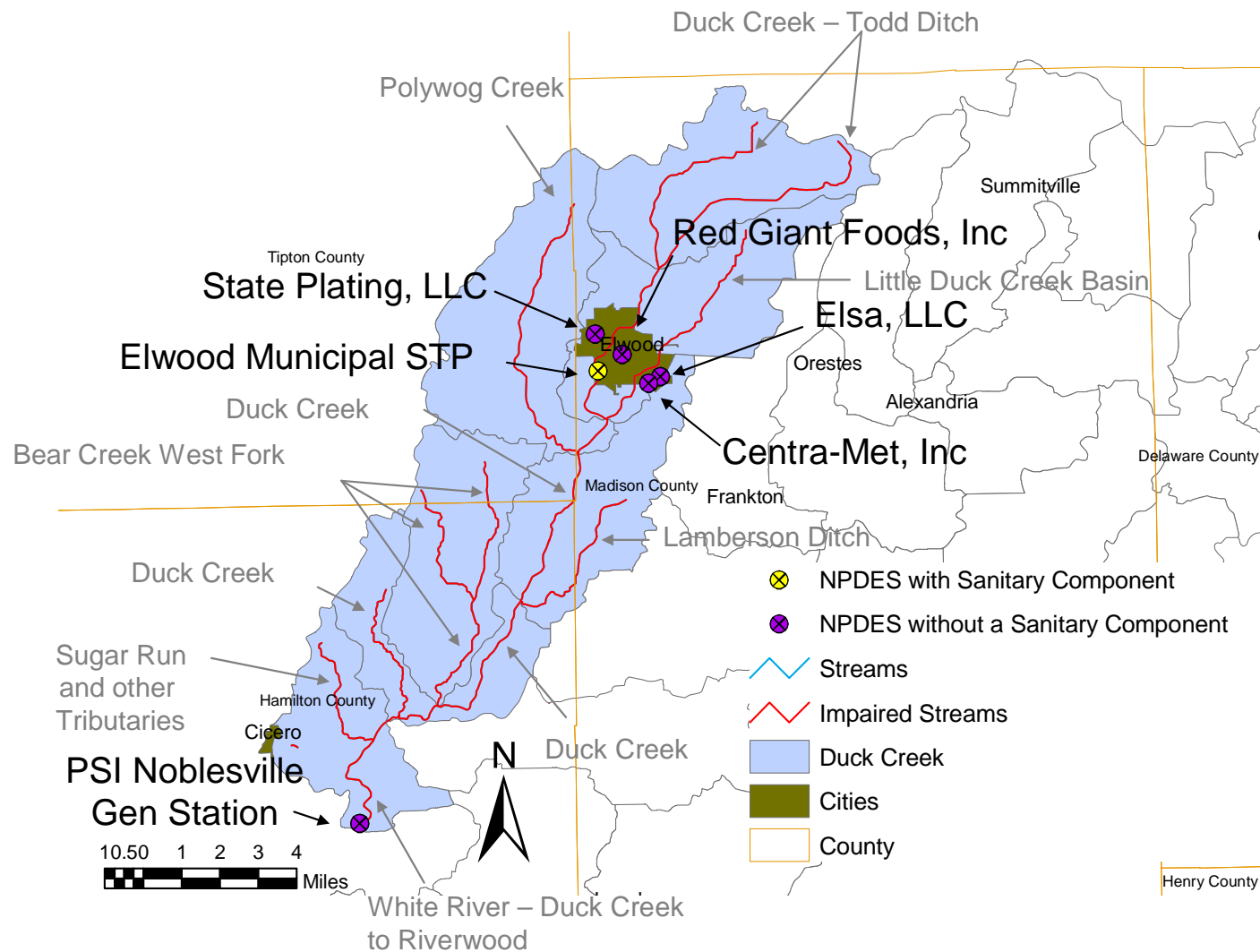


Figure 4-1 NPDES Facilities in the Duck Creek Watershed

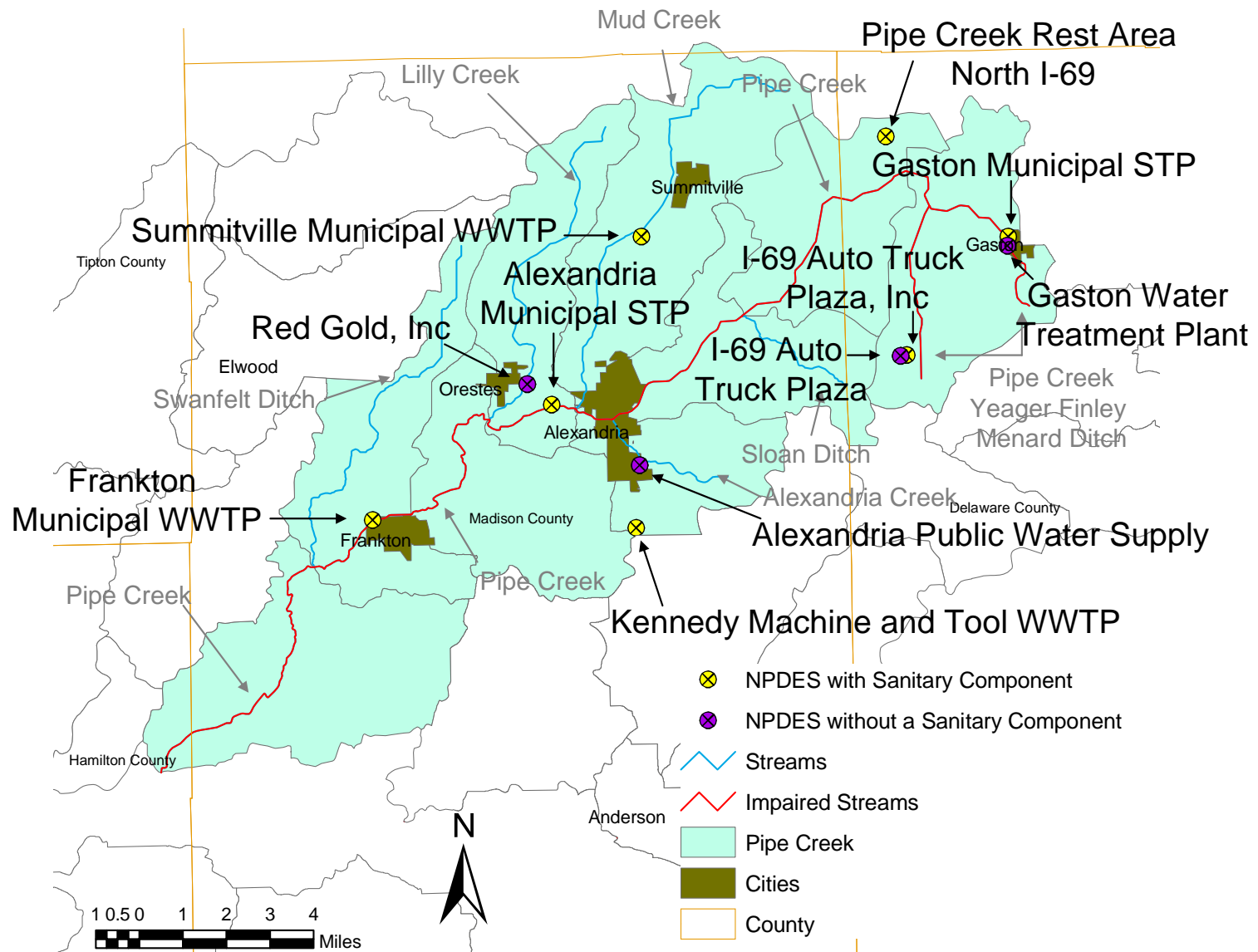


Figure 4-2. NPDES Facilities in the Pipe Creek Watershed

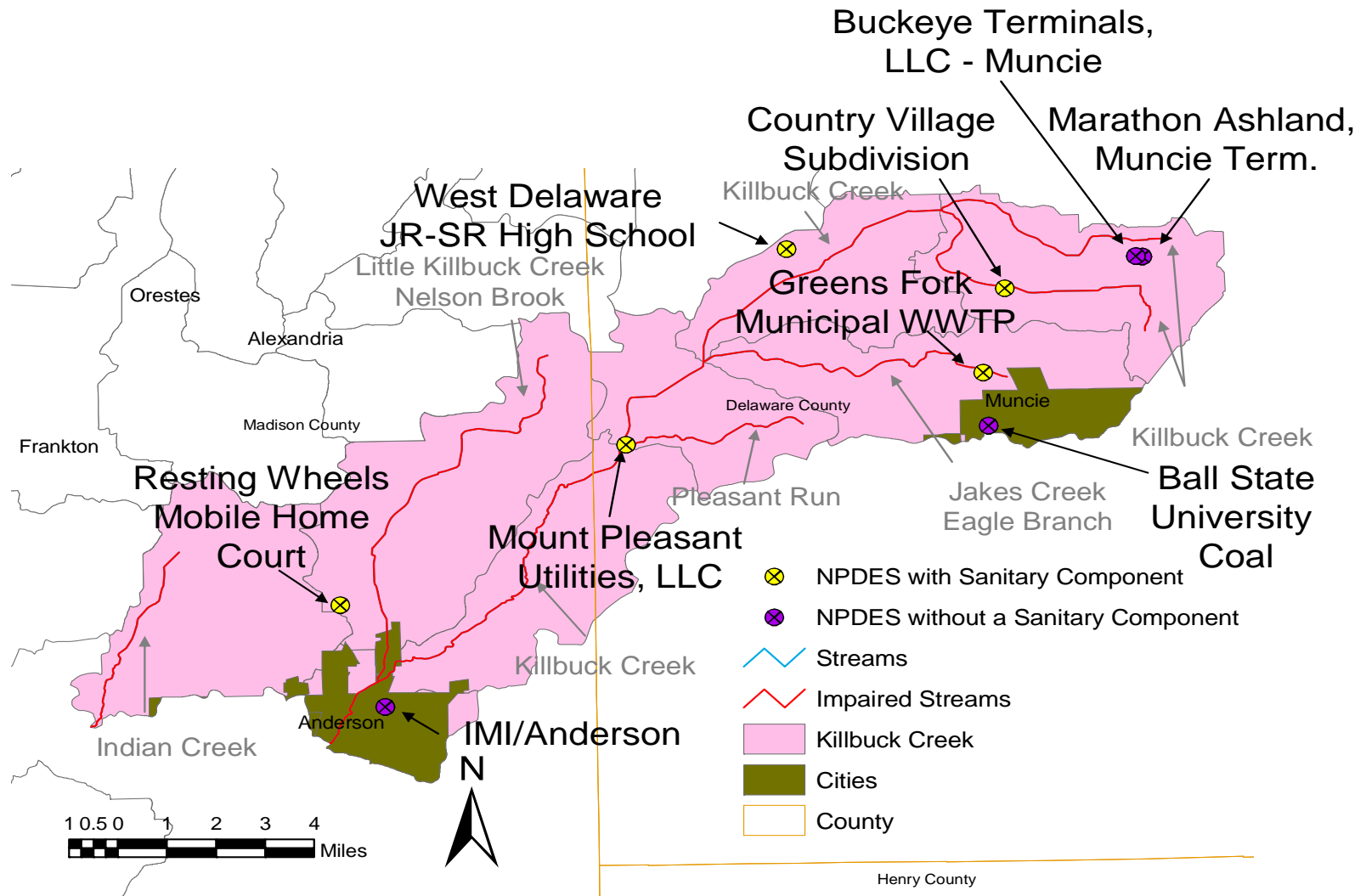


Figure 4-3. NPDES Facilities in the Killbuck Creek Watershed

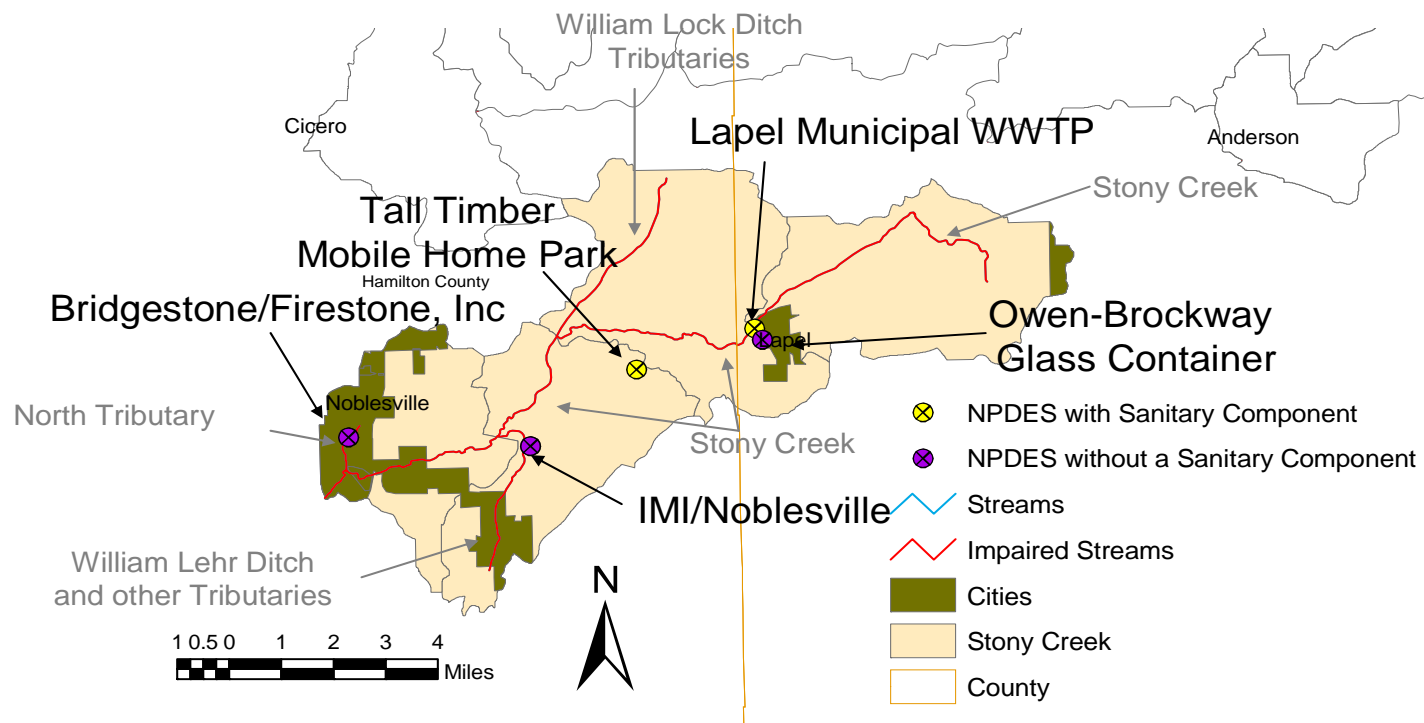


Figure 4-4. NPDES Facilities in the Stony Creek Watershed

4.1.2 COMBINED SEWER OVERFLOWS

Combined sewer systems are sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater into the same pipe. Most of the time, combined sewer systems transport all of their wastewater to a sewage treatment plant. During periods of heavy rainfall or snowmelt, however, the wastewater volume in a combined sewer system can exceed the capacity of the sewer system or waste water treatment plant. For this reason, combined sewer systems are designed to overflow and discharge excess wastewater directly to streams, rivers, or other water bodies. These overflows, called combined sewer overflows (CSOs), can contain both storm water and untreated human and industrial waste. Because they are associated with wet weather events, CSOs typically discharge for short periods of time during high flow events.

IDEM regulates CSOs in Indiana through the state's NPDES program. One key component of this program is locating all CSO outfalls for tracking purposes. In Duck Creek watershed there is one CSO community, the City of Elwood, which has 14 CSO outfalls (Figure 4-5). City of Elwood WWTP personnel (Washburn, 2004) provided locations of these CSO outfalls, which are shown in Figure 4-5. In the Agreed Order with IDEM (IDEM, 2002), the City of Elwood acknowledged that both wet weather and dry weather discharges from its CSO outfalls occurred during the period of IDEM's 2001 targeted *E. coli* sampling (April – September). The City also agreed to submit a revised CSO Plan for improving operation and maintenance of its CSO outfall structures this was submitted on December 29, 2006. As such, implementation of this CSO Plan is expected to result in *E. coli* load reductions to Duck Creek.

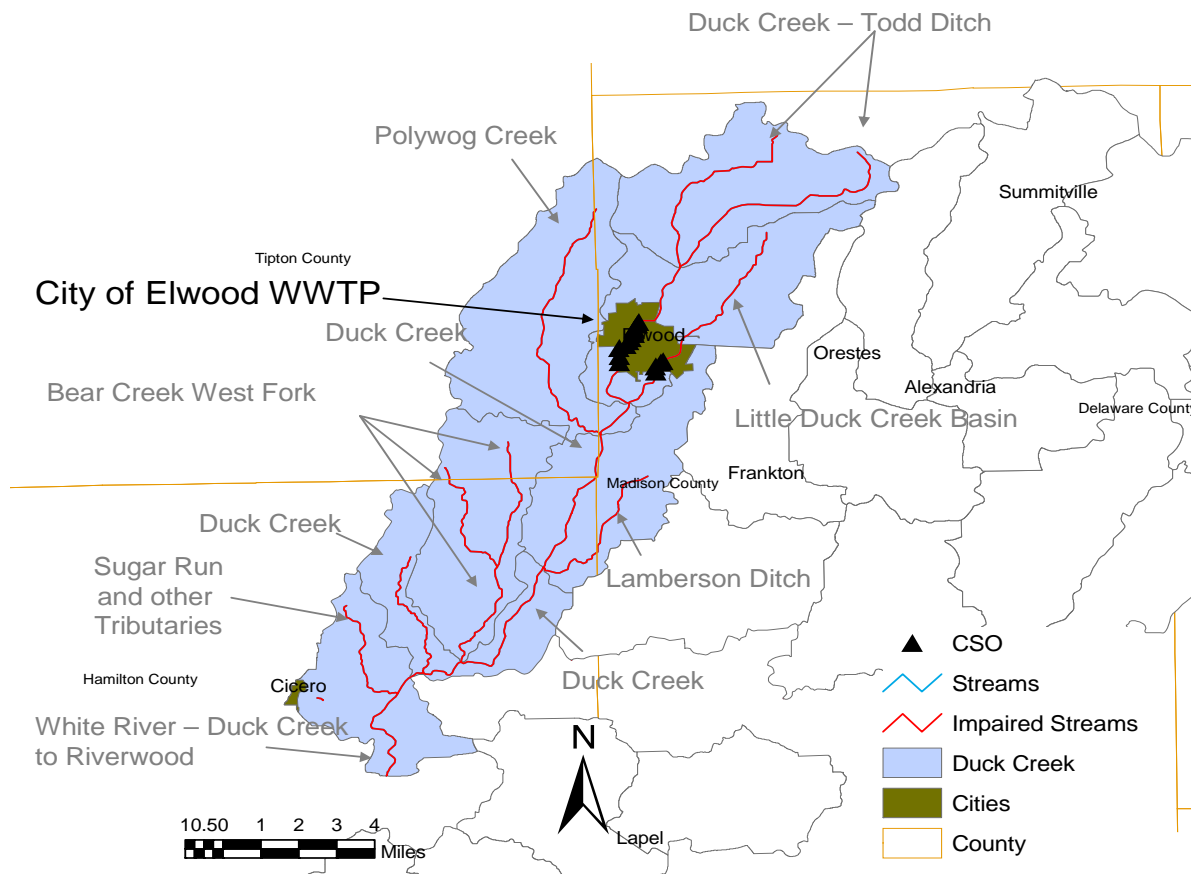


Figure 4-5 Duck Creek CSO locations

In the Pipe Creek watershed, there are two CSO communities: Alexandria and Summitville (Figure 4-6). Pierce (2004), Seal (2004), and Dow (2005) provided locational information for CSO outfalls in those communities. According to that information, Alexandria has one active CSO outfall, while Summitville has two CSO outfalls. CSO Long Term Control Plans (LTCPs) for those three communities were submitted on June 12, 2002 (Alexandria) and October 1, 2003 (Summitville). Both are currently under review.

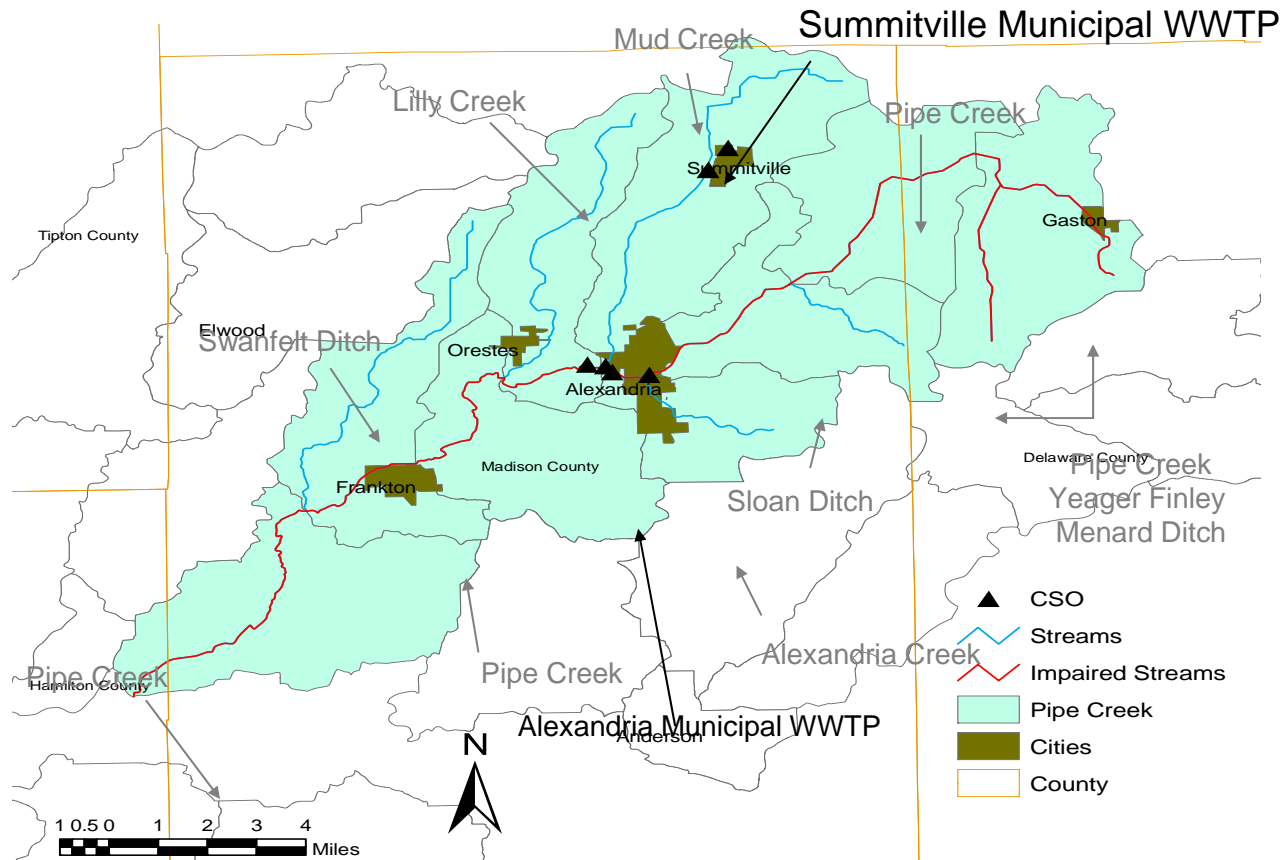


Figure 4-6 Pipe Creek CSO locations

In the Killbuck Creek watershed there are no CSO communities. While parts of both Anderson and Muncie are contained within the hydrologic boundary of the Killbuck Creek watershed, the CSO outfalls for both of the cities discharge outside the watershed to the West Fork White River.

In the Stony Creek watershed there are two CSO communities: Lapel and Noblesville (Figure 4-7). Discussions with the Hamilton County Surveyor (Thompson, 2004) and the City of Lapel's contracted WWTP design engineer (Shuck, 2004) provided information on CSOs in the Stony Creek watershed cities of Noblesville and Lapel. For Noblesville, two of the city's eight CSO outfalls discharge to the North Tributary subwatershed of Stony Creek. Noblesville's LTCP was submitted on August 29, 2003. In Lapel, no CSO outfalls exist. However, the municipal WWTP had a wet well that had the potential to overflow and discharge to either a stormwater outfall or the WWTP outfall. The Lapel wet well overflow condition was corrected in 2005. Figure 4-7 shows the locations of the Noblesville CSO outfalls and the Lapel WWTP in the Stony Creek watershed.

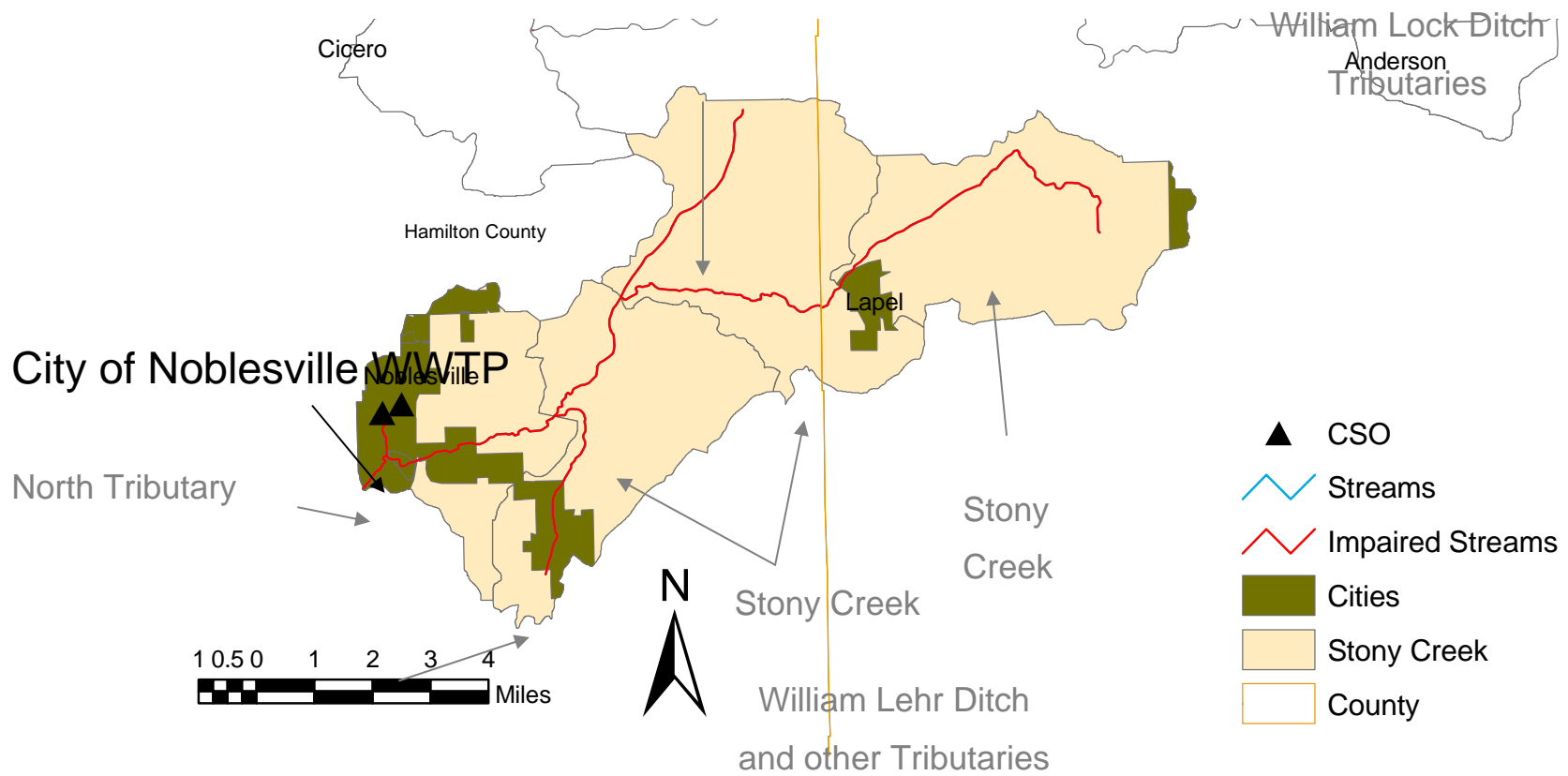


Figure 4-7 Stony Creek CSO locations

In order to estimate CSO loads from these sources, some assumptions were made regarding typical CSO discharge quality and volume. Typical discharge *E. coli* concentrations were assumed to be equal to the average of the values used for the Fall Creek and Pleasant Run TMDLs (IDEM, 2003 and IDEM, 2003a), which were determined from targeted CSO *E. coli* sampling efforts in 2001 (Appendix A). The NPDES Long Term Control Plan is in the permitting process. The Long Term Control Plan will better refine the necessary loading and reductions necessary to comply with water quality standards.

4.1.3 SANITARY SEWER OVERFLOWS

Sanitary Sewer Overflow (SSOs) are, generally, untreated or partially treated sewage overflows from a sanitary sewer collection system. They are considered an unpermitted activity and are an illegal discharge. There is one SSO within the Pipe Creek watershed, located at the headworks of the Frankton WTP.

4.1.4 CONCENTRATED ANIMAL FEEDING OPERATIONS

The removal and disposal of the manure, litter, or processed wastewater that is generated as the result of concentrated animal feeding operations falls under the regulations for concentrated animal feeding operations (CAFOs). CAFO rules can be found at 327 IAC 5-4-3 (effective 12/28/06) and 327 IAC 5-4-3.1 (effective 3/24/04).

There are no CAFO's in the Duck Creek, Pipe Creek, Killbuck Creek, or Stony watersheds.

4.1.5 MS4 STORMWATER COMMUNITIES

E. coli bacteria loads to receiving waters can be supplemented by stormwater runoff, as bacterial matter can accumulate on land surfaces and wash off during wet weather events. Under Phase II of the NPDES stormwater program, certain smaller urbanized areas that contain Municipal Separate Storm Sewer Systems (MS4s) are required to apply for a NPDES permit and to establish stormwater management plans that entail the implementation of mitigation controls. MS4 permits have been issued in the state of Indiana. Guidelines for MS4 permits and timelines are outlined in Indiana's Municipal Separate Storm Sewer System (MS4) Rule 13 (327 IAC 15-13-10 and 327 IAC 15-13-11). Once these permits have been issued and implemented, they will improve water quality and address storm water impacts in the related watersheds. The Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek watersheds contain parts of four communities (Anderson, Muncie, Noblesville, and Alexandria) and three

counties (Delaware, Hamilton, and Madison) that are designated as NPDES Phase II MS4 entities (IDEM, 2004c).

4.1.6 STRAIGHT PIPES

Septic systems that discharge raw sewage directly to streams without treatment, are known as “straight pipes”. In areas without access to central sewer systems, onsite septic systems should be approved and permitted by the Indiana Department of Health. According to the Hamilton County Health Department (McNulty, 2005), although there are not currently any known straight pipes in the area, Health Department staff do occasionally find wastewater connections from homes, typically older homes in very rural areas, leading directly into a stream. When such a situation arises, the Health Department performs a confirmation with a water sample and a dye study. All connections discharging untreated wastewater are illegal and immediate action, in the form of septic system installation, is required within thirty days. The current *E. coli* contributions associated with straight pipes are considered in the overall approach to estimating loads from septic systems.

4.2 NONPOINT SOURCES

Nonpoint sources of bacteria are diffuse and cannot be identified as entering the waterbody at a single, discrete location. Nonpoint sources typically involve land activities that contribute bacteria to waterbodies via runoff during precipitation events. As such, nonpoint sources are much more difficult to identify and quantify than are point sources. For the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek watersheds, significant nonpoint sources of *E. coli* include failing septic systems, runoff from agriculture row crop and pasture lands, wildlife, and domestic pet waste.

4.2.1 SEPTIC SYSTEMS

On-site septic systems that are functioning properly generally do not contribute *E. coli* loadings to surface waters. In central Indiana, however, there are a number of factors that can play a role in septic system failures, such as high seasonal water tables, limited leach field filtration due to areas of compact glacial till and bedrock interference, and high filtration due to leach field interaction with quickly draining soils. When septic systems fail, raw sewage may be transported to receiving surface waters before sufficient bacterial decay is completed. The presence of agricultural tile drains throughout central Indiana is another factor that tends to worsen *E. coli* loading from septic systems,

Additionally, there is anecdotal evidence (Martin, 2005) that some septic systems for newer developments in the study area are experiencing leach field interference with retired and/or abandoned tile drains. This has become evident as some of these abandoned tile drains have collapsed, creating limited filtration conditions that, in turn, have caused septic system backups during wet weather events

According to a 1997 survey of county health officials (Taylor et al., 1997), the percentage of failing septic systems in each county (including illegally connected to tile drains and straight pipes to stream) ranged from 15% to as high as 75%. There are also many older homes in rural areas where septic systems were constructed without appropriately sized leach fields.

4.2.2 AGRICULTURE

For nonpoint sources involving agricultural activities, potential sources include the application of agricultural manure to row crop and pasture lands and the deposition of manure onto pasture lands from free-ranging livestock.

4.2.2.2 Land Application of Agricultural Manure

Processed agricultural manure is generally collected in waste lagoons and applied to land surfaces from late spring to early fall. Because a high percentage of lands surrounding the impaired waters in the four watersheds are utilized for row crops and grazing, loading from these areas must be considered. In areas where manure is applied to cropland and pasture, *E. coli* rates from livestock are calculated based on manure application rates and literature values for bacteria counts in manure from different livestock sources. Manure application rates from different animal sources can vary according to management practices.

For the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek watersheds, estimates of the cow, pig, and sheep populations in the watershed were calculated using the total numbers of cows, pigs, and sheep in Delaware, Madison, Hamilton, and Tipton counties (Table 4-2, USDA (2002)) and a GIS analysis to determine the percentage of each county included in the four watershed study area (Table 4-3). Table 4-4 shows the estimates of farm animals in the study area portions of Delaware, Madison, Hamilton, and Tipton counties.

Table 4-2. USDA Cow, Pig, and Sheep Populations in Delaware, Hamilton, Madison, and Tipton Counties [USDA (2002) except where noted]

County	Beef	Milk	Other	Total	Swine	Sheep
Delaware	1,300	358	2,184	3,842	22,691	601
Hamilton	1,268	302	2,346	3,916	24,045	988
Madison	1,730	154	2,456	4,340	26,875	655
Tipton	239*	60*	1,349	1,648	42,889	629

Numbers in **BOLD** from USDA (1997); * estimated from other counties

Table 4-3. Calculated Percentages of Each County within the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek Watersheds

Acreage	County	Study Area	% in Area
Delaware	253,212	57,647	22.77%
Hamilton	257,348	42,398	16.47%
Madison	289,734	148,260	51.17%
Tipton	166,592	18,733	11.24%

Table 4-4. Estimates of Cow, Pig, and Sheep Populations within the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek Portions of Delaware, Hamilton, Madison, and Tipton Counties

County	Beef	Milk	Other	Total	Swine	Sheep
Delaware	296	82	497	875	5,166	137
Hamilton	209	50	387	645	3,961	163
Madison	885	79	1,257	2,221	13,752	335
Tipton	27	7	152	185	4,823	71

4.2.2.3 Direct Deposition of Manure from Pasture Lands

Fecal matter from livestock can be deposited directly to the stream in instances where livestock have stream access, or the fecal matter can be transported to the stream in runoff from grazing or pasture lands. During a precipitation event, fecal material containing *E. coli* is transported to the streams. Figures 2-10 through 2-13 show the land uses associated with each watershed. While the majority of land in each of the four watersheds is in row crops, there are also smaller patches of land area associated with a grazing/pasture use. These pasture areas are commonly adjacent to tributaries of Duck Creek, Killbuck Creek, Pipe Creek, and Stony Creek.

In Hamilton County's recent study of the Stony Creek watershed, staff noted cattle with direct access to a stream and trampling of riparian vegetation by cattle from pasture areas adjacent to the waterbody (Baker and Nelson, 2004).

For the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek watersheds, estimates of the free-ranging animal populations in the watershed were calculated by subtracting the CFO populations in Table 4-2 from the total numbers estimated in Table 4-4. Table 4-5 shows the resulting estimates of farm animals in the study area that are not associated with CFOs.

Table 4-5. Estimates of Non-CFO Related Cow, Pig and Sheep Populations within the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek Portions of Delaware, Hamilton, Madison, and Tipton Counties

County	Beef	Milk	Other	Total	Swine	Sheep
Delaware	296	82	497	875	1,602	137
Hamilton	209	50	387	645	545	163
Madison	268	0	136	404	4,444	335
Tipton	27	7	152	185	3,303	71

4.2.3 CONFINED FEEDING OPERATIONS

The removal and disposal of the manure, litter, or processed wastewater that is generated as the result of confined feeding operations falls under the regulations for confined feeding operations (CFOs) and concentrated animal feeding operations (CAFOs). The CFO regulations (327 IAC 16, 327 IAC 15) require that operations “not cause or contribute to an impairment of surface waters of the state”. IDEM regulates these confined feeding operations under IC 13-18-10, the Confined Feeding Control Law. The rules at 327 IAC 16, which implement the statute regulating confined feeding operations, were effective on March 10, 2002. The rule at 327 IAC 15-15, which regulates concentrated animal feeding operations and complies with most federal CAFO regulations, became effective on March 24, 2004, with two exceptions. 327 IAC 15-15-11 and 327 IAC 15-15-12 became effective on December 28, 2006. CFO and CAFO rules can be found at 327 IAC 5-4-3 (effective 12/28/06) and 327 IAC 5-4-3.1 (effective 3/24/04). The difference between the two feeding operation is that Concentrated Animal Feeding operations fall under Federal regulation and Confined feeding operations fall under State regulations. Due to this difference CAFO loads fall under WLA and CFO loads fall under LA.

The animals raised in confined feeding operations produce manure that is stored in pits, lagoons, tanks and other storage devices. The manure is then applied to area fields as fertilizer. When stored and applied properly, this beneficial re-use of manure provides a natural source for crop nutrition. It also lessens the need for fuel and other natural resources that are used in the

production of fertilizer. Confined feeding operations, however, can also pose environmental concerns, including the following:

- Manure can leak or spill from storage pits, lagoons, tanks, etc.
- Improper application of manure can contaminate surface or ground water.
- Manure over-application can adversely impact soil productivity.

The locations of confined feeding operations in the Duck Creek, Pipe Creek, Killbuck Creek and Stony Creek watersheds are shown in Figure 4-8, 4-9, 4-10, 4-11.

Thirteen (13) active CFO facilities have been identified in the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek watersheds (IDEM, 2004b; IDEM, 2005). Table 4-6 lists these 13 active facilities in the four watersheds.

Table 4-6. Active CFOs in the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek Watersheds

Log #	County	Watershed	Farm Name
1419	Hamilton	Duck	AMORA SOW UNIT
3057	Hamilton	Duck	BRYANT PREMIUM PORT LLC
802	Madison	Duck	WILLIAMS FARMS INC
4643	Madison	Duck	WIMMER FARMS
1011	Tipton	Duck	IDLEWINE
3690	Delaware	Killbuck	JACOBS FARM
2729	Delaware	Pipe	DALE K RINKER
938	Madison	Pipe	SHUTER SUNSET FARMS
2389	Madison	Pipe	SIMMERMON FARMS #2
3540	Madison	Pipe	MCCORD FARMS INC #1
6199	Madison	Pipe	WILLEMSSEN DAIRY
504	Hamilton	Stony	ROBERT M ANDERSON
1957	Madison	Stony	SIMMERMON FARMS #1

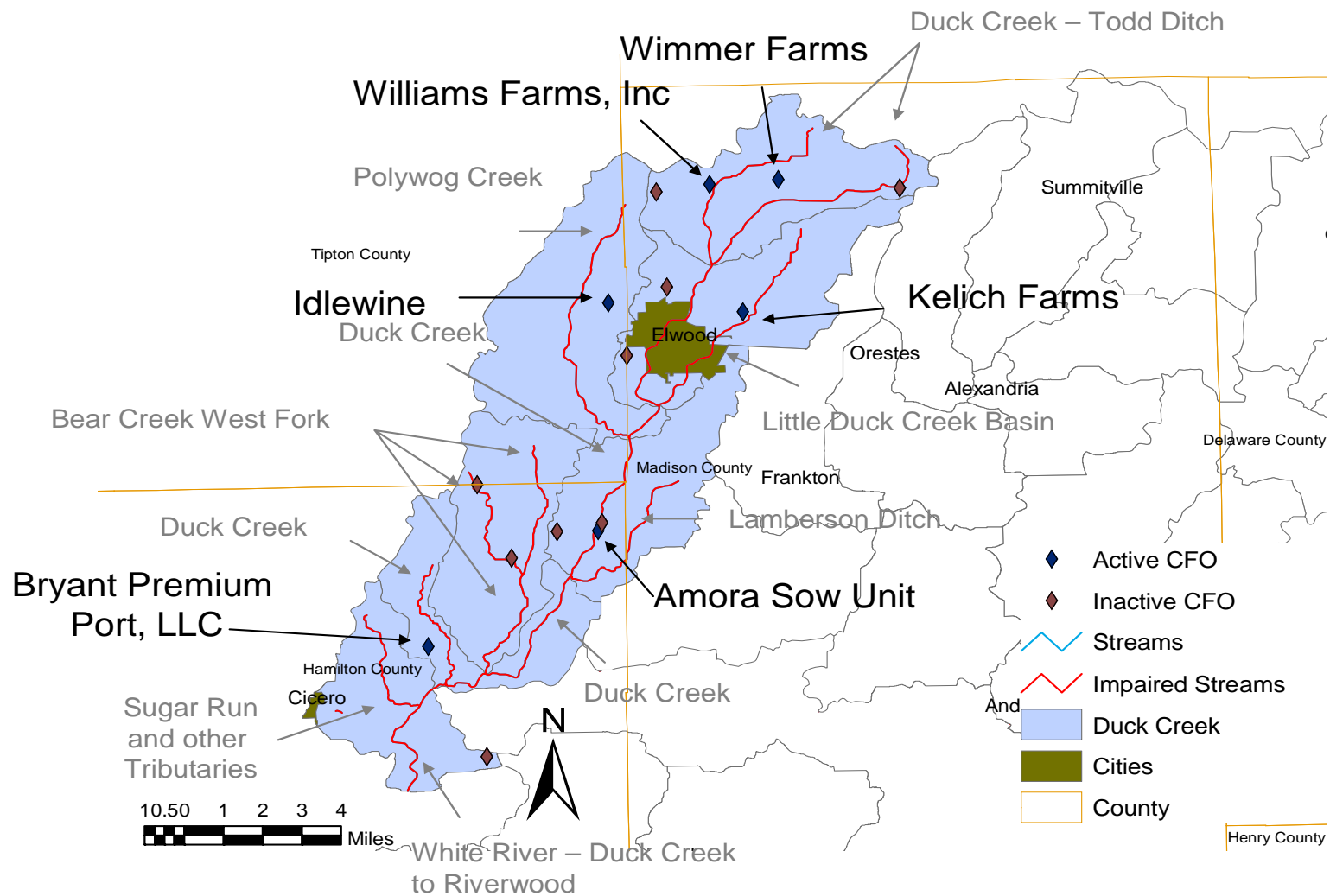


Figure 4-8. Active CFO Locations in the Duck Creek Watershed

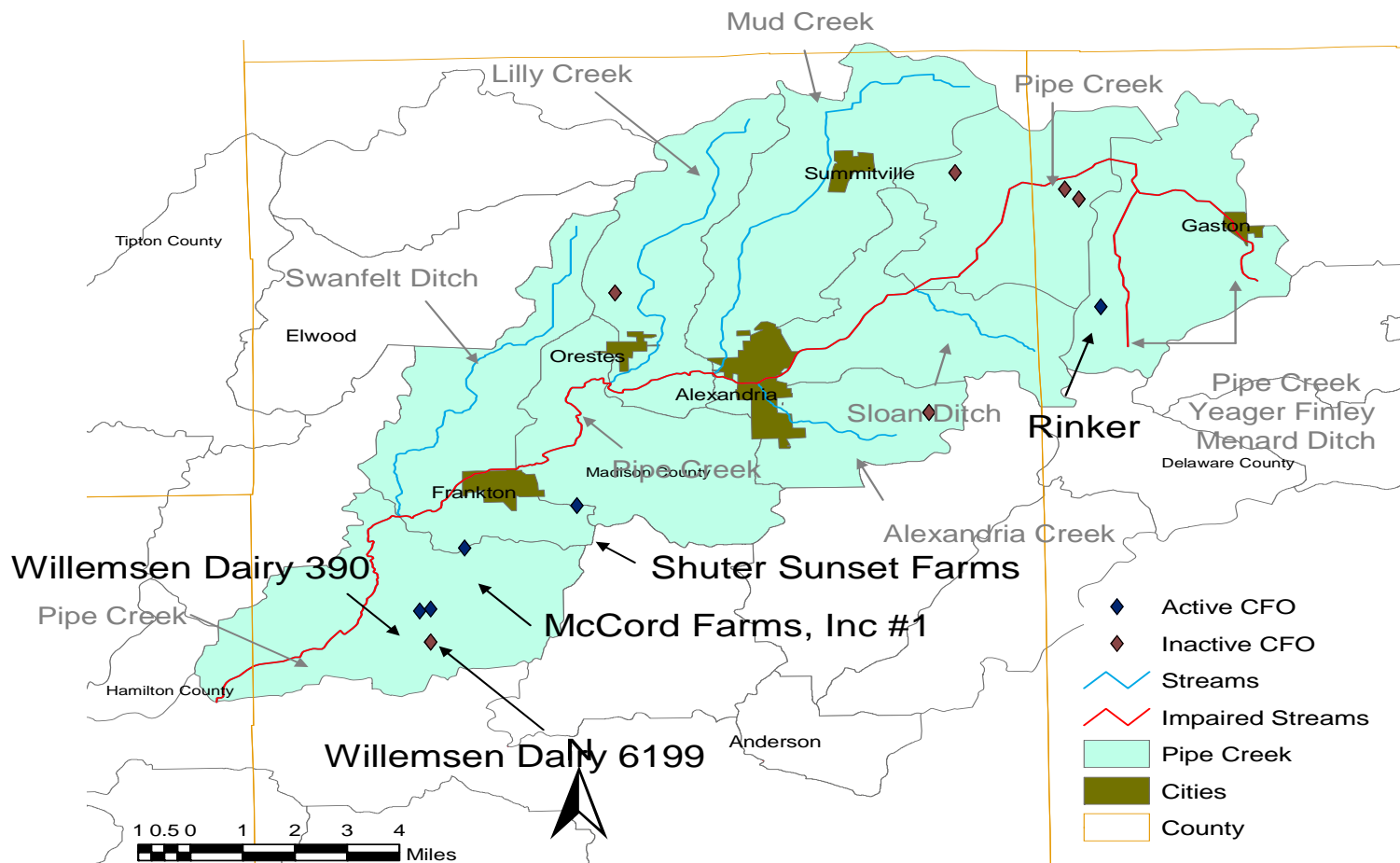


Figure 4-9. Active CFO Locations in the Pipe Creek Watershed

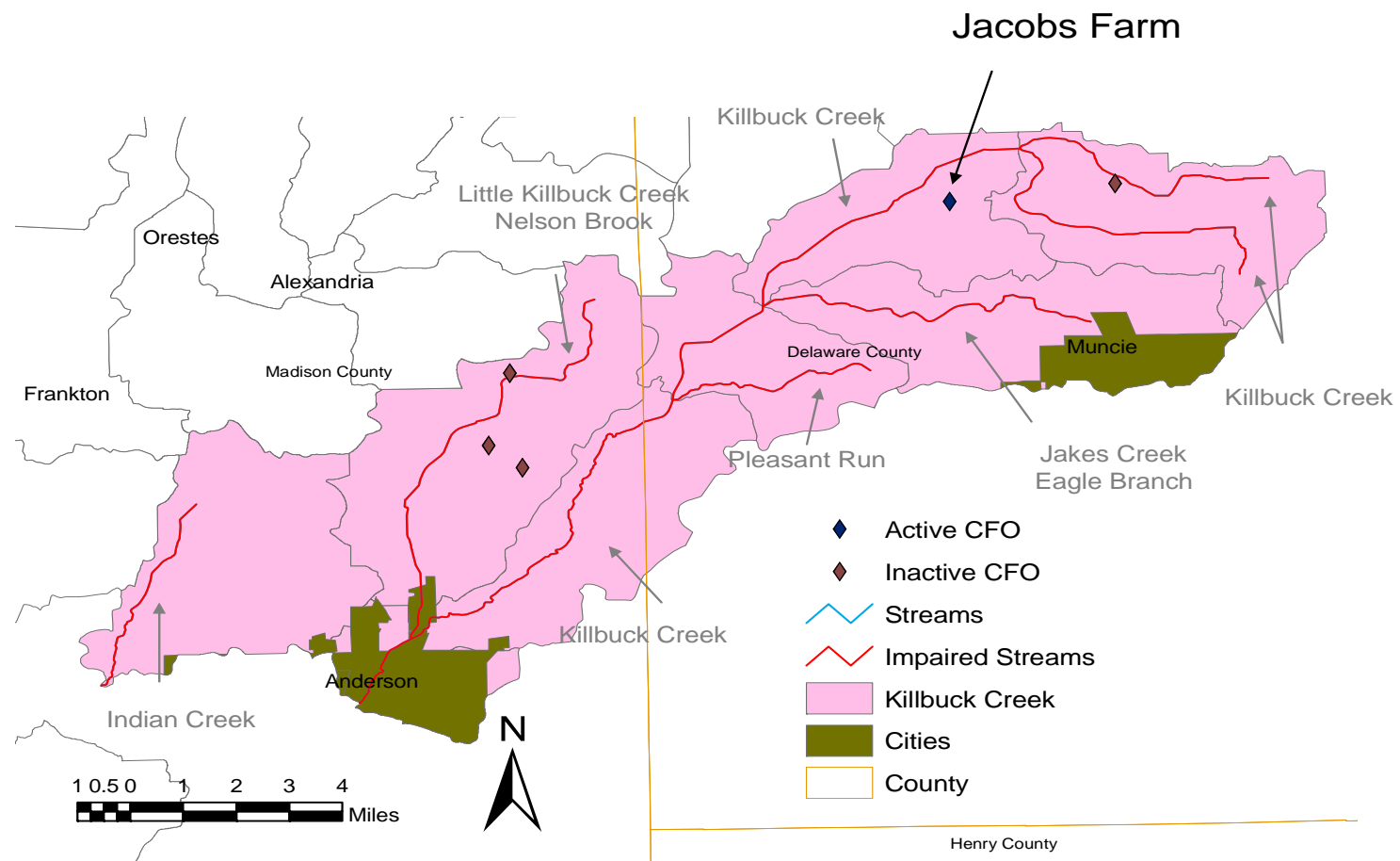


Figure 4-10. Active CFO Locations in the Killbuck Creek Watershed

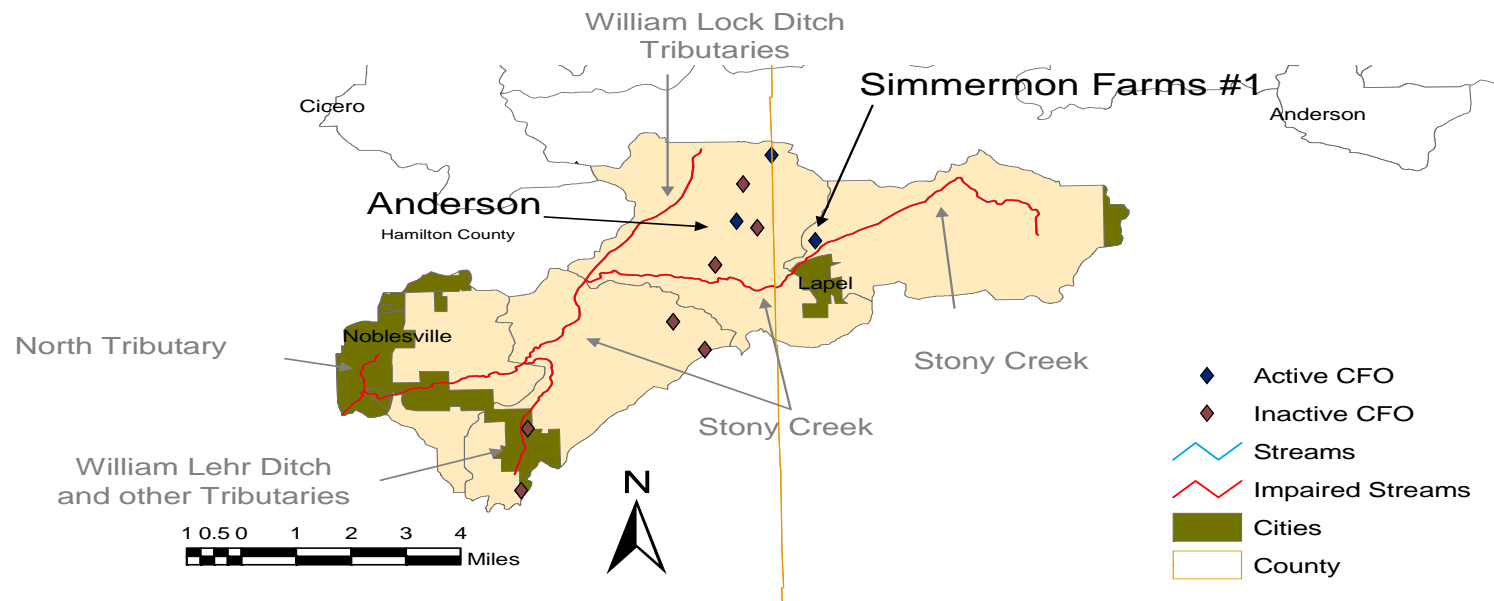


Figure 4-11. Active CFO Locations in the Stony Creek Watershed

4.2.4 WILDLIFE

As for free-ranging livestock, fecal matter from wildlife can be deposited directly to the stream, or it can be transported to the stream in surface runoff from woods, pastureland, and cropland. Direct deposition to streams varies with species.

According to personnel from Indiana Department of Natural Resources (IDNR) District 11 (includes Delaware County), the predominant wildlife species in the study area are deer, raccoon, and Canadian geese (Hanauer, 2005). Estimated populations for these species were determined assuming that all land use categories within the watersheds are accessible to the species and then by estimating the population density (animals/acre) of each species.

For deer, the IDNR is hesitant to provide population or density estimates for the species, although the number of deer/automobile collisions per billion miles traveled in Indiana are available for 1991-2003 via IDNR Deer Harvest Summaries (IDNR, 1999 – 2003). This statistic is used by IDNR as an index of deer population trends. According to McCreedy (1995) the Indiana deer population in 1991 was approximately 350,000. Using this number, the numbers of deer harvested each year between 1991-2003, the number of deer/automobile collisions that occurred each year between 1991-2003, and an assumption that one third of the deer herd is reproduced each year, estimates of the Indiana deer population were made for each of the years between 1991-2003. The estimated average annual deer population over that period is 383,359, or 0.0175 deer/acre.

The raccoon population density was determined in a similar fashion. IDNR reports that raccoon densities in Indiana can vary between 1 animal/acre and 1 animal/40 acres (IDNR, 2005). IDNR also uses road kill surveys for a relative index of raccoon population trends in the state. According to these surveys, the relative index for north central Indiana has been the highest in the state for the last two years (Plowman, 2003; Plowman, 2004). A ranking of the reported indices for 2002, 2003, and March 2004 shows the average index for north central Indiana to be 64.5. By fitting this relative ranking into a distribution between 1/acre and 1/40 acres, an estimate of one raccoon / 14.2 acres (or 0.07 / acre) is estimated for north central Indiana.

According to the IDNR Water Fowl Research Biologist, indices for Canadian geese population estimates in 2001-2004 have led to statewide population estimates between 80,200 and 121,054 birds (McNew, 2005). The average estimate over that time frame is 98,965 birds, or 0.0042 / acre.

4.2.5 DOMESTIC PETS

Cats and dogs can also be potential sources of *E. coli* within a watershed. As with wildlife, fecal matter deposited by domestic animals can accumulate and wash off during wet weather events. The domestic animals source category is expected to be much more significant in urban and suburban areas, where greater densities of pets are typically found.

5.0 TECHNICAL APPROACH

The TMDL represents the maximum loading that can be assimilated by the waterbody while still achieving the water quality standard (WQS). As indicated in the Numeric Targets section of this document, the target for this *E. coli* TMDL is 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period and 235 per one hundred milliliters as a single sample maximum from April 1 through October 31. Concurrent with the selection of a numeric concentration endpoint, TMDL development also defines the critical conditions that will be used when defining allowable levels. Many TMDLs are designed as the set of environmental conditions that, when addressed by appropriate controls, will ensure attainment of WQS for the pollutant. For example, the critical conditions for the control of point sources in Indiana are given in 327 IAC 5-2-11.1(b). In general, the 7-day average low flow in 10 years (Q7, 10) for a stream is used as the design condition for point source dischargers. However, *E. coli* sources to the Duck, Pipe, Killbuck and Stony Creek watersheds arise from a mixture of dry and wet weather-driven conditions, and there is no single critical condition that would achieve the *E. coli* WQS. For the Duck, Pipe, Killbuck and Stony watersheds and the contributing sources, there are a number of different allowable loads that will ensure compliance, as long as they are distributed properly throughout the watershed.

For most pollutants, TMDLs are expressed on a mass loading basis (e.g. pounds per day). For *E. coli* indicators, however, mass is not an appropriate measure because *E. coli* is expressed in terms of organism counts (or resulting concentration) (USEPA, 2001). Meeting the Water Quality Standards (WQS) of 125 colony forming unit (cfu) per 100 mL as a geometric mean and 235 cfu/100 mL is the overall goal of the TMDL. The geometric mean *E. coli* WQS allows for the best characterization of the watershed. The geometric mean provides a more reliable measure of *E. coli* concentration because it is less subject to random variation (USEPA, 2004). Therefore, the percent reduction goals are based upon meeting the 125 cfu/100mL geometric mean standard. This *E. coli* TMDL is concentration-based consistent with 327 IAC 5-2-11.1(b) and 40 CFR, Section 130.2 (i) and the TMDL is equal to the geometric mean *E. coli* WQS for each month and the single samples maximum *E.coli* WQS for the recreational season (April 1through October 31).

The Wasteload Allocation (WLA) is set at 125 cfu/100mL, and the 235 cfu/100 mL single day standard. The LA is set at 112.5 cfu/100mL geometric mean target and 211.5 cfu/100mL single day target. The WLA will be met by compliance with current permits and long term control plans. The LA will use the geometric mean of each sampling location to determine the reduction necessary to comply with WQS at each site (Appendix F).

5.1 INCREMENTAL WATERSHED LDC APPROACH (EXPERIMENTAL)

The incremental watershed LDC approach is a stepwise process that uses geographic information systems (GIS) data, water quality and flow information recorded at discrete locations within each simulated watershed, literature-based estimates of bacterial loadings from individual source categories and activities, and spreadsheet tools that provide estimates of the instream effects associated with specific source load reductions in each simulated subwatershed.

5.2 CONCLUSION FOR INCREMENTAL WATERSHED LDC APPROACH

The incremental watershed LDC approach was used for this project on an experimental basis. It has been determined that this approach, while having some validity, is not the best approach for these TMDLs at this time. With some additional data and information, this approach may be viable. For the purposes of this TMDL, however, it provides only information for watershed group use. The reduction targets for the TMDL are set in the NPDES and LTCP for the WLA and the reductions table for the LA. The information for the incremental watershed approach can be found in Appendix G.

6.0 ALLOCATIONS

TMDL Development

The TMDL represents the maximum loading that can be assimilated by the waterbody while still achieving the Water Quality Standard (WQS). As indicated in the Numeric Targets section of this document, the target for this *E. coli* TMDL is 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period and 235 per one hundred milliliters as a single sample maximum from April 1 through October 31. Concurrent with the selection of a numeric concentration endpoint, TMDL development also defines the critical conditions that will be used when defining allowable levels. Many TMDLs are designed as the set of environmental conditions that, when addressed by appropriate controls, will ensure attainment of WQS for the pollutant. For example, the critical conditions for the control of point sources in Indiana are given in 327 IAC 5-2-11.1(b). In general, the 7-day average low flow in 10 years (Q7, 10) for a stream is used as the design condition for point source dischargers. However, *E. coli* sources to the Duck, Pipe, Killbuck, Stony watersheds arise from a mixture of dry and wet weather-driven conditions, and there is no single critical condition that would achieve the *E. coli* WQS. For the Duck, Pipe, Killbuck, Stony watersheds and the contributing sources, there are a number of different allowable loads that will ensure compliance, as long as they are distributed properly throughout the watershed.

For most pollutants, TMDLs are expressed on a mass loading basis (e.g. pounds per day). For *E. coli* indicators, however, mass is not an appropriate measure because *E. coli* is expressed in terms of organism counts (or resulting concentration) (USEPA, 2001). Meeting the Water Quality Standards (WQS) of 125 colony forming unit (cfu) per 100 mL as a geometric mean and 235 cfu/100 mL is the overall goal of the TMDL. The geometric mean *E. coli* WQS allows for the best characterization of the watershed. The geometric mean provides a more reliable measure of *E. coli* concentration because it is less subject to random variation (USEPA, 2004). Therefore, the percent reduction goals are based upon meeting the 125 cfu/100mL geometric mean standard. This *E. coli* TMDL is concentration-based consistent with 327 IAC 5-2-11.1(b) and 40 CFR, Section 130.2 (i) and the TMDL is equal to the geometric mean *E. coli* WQS for each month and

the single sample maximum *E.coli* WQS for the recreational season (April 1 through October 31).

The Wasteload Allocation (WLA) is set at 125 cfu/100mL, and the 235 cfu/100 mL single day standard. The LA is set at 112.5 cfu/100mL geometric mean target and 211.5 cfu/100mL single day target. The WLA will be met by compliance with current permits and long term control plans. The LA will use the geometric mean of each sampling location to determine the reduction necessary to comply with WQS at each site (Appendix F).

Allocations

TMDLs are comprised of the sum of individual wasteload allocations (WLA) for point sources and load allocations (LA) for nonpoint sources and natural background levels. In addition, the TMDL must include a Margin of Safety (MOS), either implicitly or explicitly, that accounts for uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the equation:

$$\text{TMDL} = \sum \text{WLA} + \sum \text{LA} + \text{MOS}$$

The term TMDL represents the maximum loading that can be assimilated by the receiving water while still achieving WQS. The overall loading capacity is subsequently allocated into the TMDL components of WLAs for point sources, LAs for nonpoint sources, and the MOS. This *E. coli* TMDL is concentration-based consistent with USEPA regulations at 40 CFR, Section 130.2 (i).

For Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek, *E. coli* TMDLs were established via the steps described in Sections 4 and 5.

6.1 DUCK CREEK TMDL

The Duck Creek *E. coli* TMDL was conducted for 16 subwatersheds. In addition to the high percentages of row crop and pasture lands within the watershed, the city of Elwood also has 14 CSOs and a recent history of discharge violations (both WWTP and CSO discharges). An existing Agreed Order (IDEM, 2002) between the City of Elwood and IDEM stipulates additional monitoring and planning requirements for the Elwood discharges. It is expected that these requirements will result in significant *E. coli* load reductions from these sources.

6.2 PIPE CREEK TMDL

The Pipe Creek *E. coli* TMDL was conducted for 9 subwatersheds. In addition to high percentages of row crop and pasture lands, the watershed also includes the communities of Alexandria, Frankton, Summitville, Gaston, and Orestes. There are 7 NPDES discharges in the watershed that may potentially provide *E. coli* loadings to Pipe Creek. One of those permits is for the City of Summitville's two CSO outfalls. The cities of Frankton and Alexandria also have active CSO outfalls, one in each community.

6.3 KILLBUCK CREEK TMDL

TMDL components were established for each of the 12 Killbuck Creek subwatersheds in Delaware and Madison counties. The watershed includes portions of the cities of Muncie and Anderson and 10 NPDES discharges with a potential for *E. coli* contribution. There are no CSO communities in this watershed.

6.4 STONY CREEK TMDL

The Stony Creek watershed contains 17 subwatersheds, including all of the Lapel community, a small portion of Anderson, and a portion of Noblesville. There are two CSOs in the watershed from the City of Noblesville.

6.5 WASTELOAD ALLOCATION

The WLA for all permitted facilities is set at the WQS of 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period and 235 per one hundred milliliters as a single samples maximum from April

1 through October 31. The WLA for straight pipe discharges is set to 0 per one hundred milliliters.

The CSO WLA will be addressed in the LTCP which will insure that the CSOs do not cause or contribute to a violation of WQS.

The SSO WLA is set to 0 per one hundred milliliters, since SSOs are considered illegal discharges.

6.6 LOAD ALLOCATION

The LA for nonpoint sources is equal to the WQS of 112.5 cfu per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period and 211.5 cfu per one hundred milliliters as a single sample maximum from April 1 through October 31. The LA will use the geometric mean of each sampling location to determine the reduction necessary to comply with WQS at each site (Appendix F).

Load allocations may be affected by subsequent work in the watershed. The Madison, Delaware and Hamilton County Soil & Water Conservation Districts have Clean Water Act Section 319 funding to create or have created watershed management plans for these watersheds.

6.7 COMPREHENSIVE ASSESSMENT

The *E. coli* load percent reductions for the WLA and LA components of the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek TMDLs are shown in Attachment D. Based on the water quality duration curves, it can be concluded that the majority of sources of *E. coli* in this watershed are nonpoint sources. The LA reductions in most of the targeted watersheds are not unexpectedly high, due to the large amounts of agriculture, failing septic systems, straight pipe septic systems and the populations of wildlife in the watersheds.

7.0 MARGIN OF SAFETY

The Margin of Safety (MOS) is a required component of a TMDL that accounts for the uncertainty in the linkage between the sources and the receiving water quality. The MOS is often included implicitly into conservative assumptions that are used to develop the TMDL. Alternatively, the MOS may be explicitly identified as a percentage of the TMDL or as a separate load quantity (USEPA, 1991).

For the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek TMDLs, an explicit MOS of 10% is incorporated into the Load Allocation portion of the TMDL. This is due to the fact that the largest *E.coli* load to the watershed is from nonpoint sources. The MOS is defined to account for any uncertainty associated with estimates of existing loads, spatial distribution of land uses and soils, instream *E. coli* decay rates, and achievable load reduction efficiencies of the referenced management practices. When applied to the Indiana single-sample *E.coli* standard of 235 CFU / 100 mL, the 10% MOS value corresponds to that loading which would account for instream *E.coli* concentrations of 23.5 CFU / 100 mL. Accordingly, the allowable *E.coli* load for each assessment location corresponds to that which would result in instream concentrations of no more than 211.5 CFU / 100 mL.

The allowable *E.coli* load is further reduced at monitoring locations where the geometric mean of the estimated concentrations, resultant from the above reductions, is still above the geometric mean standard of 125 CFU / 100 mL. For those locations, additional *E.coli* load reductions are applied until the resultant geometric mean of the estimated concentrations is no more than 10% below the geometric mean standard (i.e. no more than 112.5 CFU / 100 mL).

8.0 SEASONAL VARIABILITY

Seasonality in the TMDL is addressed by expressing the TMDL in terms of the *E. coli* WQS for total body contact during the recreational season (April 1st through October 31st) as defined by 327 IAC 2-1-6(d). There is no applicable total body contact *E. coli* WQS during the remainder of the year in Indiana. Because this is a concentration-based TMDL, *E. coli* WQS will be met regardless of flow conditions in the applicable season.

9.0 PUBLIC PARTICIPATION

All TMDLs are conducted with input from the general public. This input is typically provided via stakeholder meetings held within the watersheds. An initial kickoff stakeholder meeting for the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek TMDLs was held on August 25, 2004, at the Anderson Public Library, 111 East 12th Street, Anderson, IN. During that meeting, IDEM personnel described the Indiana TMDL Program, discussed the specific reasons why TMDLs are being performed in the four watersheds, identified specific water quality and public health concerns regarding *E. coli*, and distributed a questionnaire to attendees to help identify additional sources of data that could be instrumental to the TMDLs.

Additional public meetings were held on April 7, 2005, in Anderson, IN and Noblesville, IN, to present the draft TMDL report. Written public comments to the draft TMDL were accepted through May 6, 2005.

10.0 REASONABLE ASSURANCE

The TMDLs established for Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek show that significant reductions in *E. coli* are required in each watershed in order to meet water quality standards. The most significant sources of *E. coli* include activities associated with the agricultural application of manure, livestock (CAFO, CFO, and other), failing septic systems, wildlife, domestic animals, and CSOs. Reasonable assurance activities are programs that are in place or will be in place to assist in meeting the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek watershed TMDL allocations and the *E. coli* Water Quality Standards (WQS).

Confined Feeding Operations and Confined Animal Feeding Operations.

CFOs and CAFOs are required to manage manure, litter, process wastewater pollutants in a manner that does not cause or contribute to the impairment of *E. coli* WQS.

CSO Long Term Control Plans.

Indiana's existing strategy for addressing CSO compliance, via each community's Long Term Control Plan (LTCP), is expected to reduce loadings from those sources. The percent reductions associated with CSOs in these TMDLs essentially provide targeted goals for the subject LTCPs.

Existing Watershed Projects.

The White River Watershed Project is conducting a focused assessment of the Killbuck Creek/Mud Creek subwatershed. The major goals of the Killbuck/Mud Creek subwatershed project are to (1) identify all existing and failing on-site septic systems in the study area so that septic waste from those locations will be included in an ongoing sewer project, (2) identify all existing and failing agricultural drainage tiles, so that repair of the tiles can be efficiently addressed by the owners, (3) identify all existing and potential agricultural conservation practices that may be applied in the watershed, (4) establish better quantifications of the bacterial loadings from geese in the watershed, and (5) provided public outreach information, via paper maps and media outlets, regarding the sources of pollutant loadings in the watershed. This project will help to

further identify and reduce specific nonpoint sources that are contributing to the *E. coli* impairment in the Killbuck Creek watershed.

The Madison County SWCD used funds from an USEPA Clean Water Act Section 319 Grant to provide public outreach for information and prevention of nonpoint source pollution. The grant was administered through IDEM and the main purposes of the grant were:

- 1) Creation of a watershed management plan for a 14 digit HUC (Hydrologic Unit Code) watershed within Madison County.
- 2) Replacement of 4 failed conventional septic systems with 4 new alternative septic systems.
- 3) Education for the residents of Madison County about nonpoint source pollution and how to prevent it. A specific component was included to educate the public regarding the maintenance of existing conventional septic systems so as to increase the life expectancy of those systems, thus preventing failed systems from contributing to water quality problems.

This project contributed to actual *E.coli* load reductions (via replacement of the four septic systems) and well as to the potential for future reductions (via the public outreach component and watershed management plan).

As part of the Stony Creek Watershed Master Plan, Indiana University and Christopher Burke Engineering conducted a biomonitoring, water quality, and habitat assessment for the Hamilton County portion of the watershed (Baker and Nelson, 2004). Results of that study corroborated the need for livestock controls in the watershed and also provided a list of potential BMPs that could be implemented to reduce sediment and pathogen loading to the receiving waters. This list includes: (a) conservation tillage, (b) replacement of existing dammed areas with instream wetlands, (c) retrofitting of suburban retention ponds, (d) implementation of rain gardens, (e) construction of Newbury-type riffles, (f) riparian tree buffer restoration, and (g) and expansion of vegetated filter strips.

Potential Future Activities:

Nonpoint source pollution, which is the primary cause of *E. coli* impairment in this watershed, can be reduced by the implementation of “best management practices” (BMPs). BMPs are practices used in agriculture, forestry, urban land development, and industry to reduce the potential for damage to natural resources from human activities. A BMP may be structural, that is, something that is built or involves changes in landforms or equipment, or it may be managerial, that is, a specific way of using or handling infrastructure or resources. BMPs should be selected based on the goals of a watershed management plan. Livestock owners, farmers, and urban planners, can implement BMPs outside of a watershed management plan, but the success of BMPs would be enhanced if coordinated as part of a watershed management plan. Following are examples of BMPs that may be used to reduce *E. coli* runoff:

Adherence to Documented Manure Application Rates. There is a litany of state and federal guidance available for determining appropriate manure application rates. These rates typically vary with the types of animals contributing the waste, the types of crops to be cultivated, and soil characteristics. In Indiana, the Purdue University Cooperative Extension Service is a readily available resource for this type of information. Other federal or interstate sources include the Midwest Plan Service, which has published its Livestock Waste Facilities Handbook (MWPS, 1993). Other documents, such as the USEPA’s CAFO Manure Management guide (USEPA, 2004) and the Comprehensive Nutrient Management Plan section of the National Planning Procedures Handbook (USDA-NRCS, 2000) also provide guidance on appropriate manure application rates.

No-Till Farming. No-till is a year-round conservation farming system. In its pure form, no-till does not include any tillage operations either before or after planting. The practice reduces wind and water erosion, catches snow, conserves soil and water, protects water quality, and provides wildlife habitat. No-till helps control soil erosion and improve water quality by maintaining maximum residue plant levels on the soil surface. These plant residues: 1) protect soil particles and applied nutrients and pesticides from detachment by wind and water; 2) increase infiltration; and 3) reduce the speed at which wind and water move over the soil surface.

Establishment of Centralized Composting Facilities. Farmers in many agricultural regions, especially those with high densities of CAFO, CFO, and other livestock facilities, have considered creating centralized composting facilities, where farmers can bring excess manure to be composted and subsequently sold to smaller operations or other users. Other potential users might include state Departments of Transportation or construction firms that perform significant levels of landscaping. Composted manure from a centralized facility can provide an excellent topsoil supplement for these activities.

Livestock Exclusion. For CAFO, CFO, and other livestock operations, a concerted effort should be made to exclude livestock from riparian areas. This is typically implemented via fencing and the provision of alternative water sources for the otherwise free-ranging animals. With significant percentages of pasture land acreages adjacent to receiving waters in the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek watersheds, limitation of livestock access to these areas will reduce the levels of *E. coli* that are directly deposited into those surface waters. Excluding these animals from the riparian zone also provides the additional benefit of allowing re-establishment of vegetation roots in the zone, which will mitigate streambank erosion and provide additional filtering for any *E. coli* laden runoff that does make it to the stream.

Septic System Public Outreach. Many homeowners may not know when their septic systems are failing. This is particularly true for those owners whose leach fields may be intermingling with agricultural tile drains in the areas. Other homeowners may know about the septic failure, but choose not to address it due to the expense. A public outreach program should be implemented to inform residents about the potential for septic system failure in the region, with a specific focus on understanding the potential for tile drain/leach field interference. The public outreach program should also include instructions on how to identify the characteristics of a septic system, how to recognize when it is failing, what regular maintenance should be performed, and what options exist for sewage disposal. The public outreach program should also incorporate a water quality component to make residents aware of the potential negative impacts that failing systems can have.

Septic System Maintenance/Elimination. A concerted effort should also be made to identify and repair/replace failing septic systems. Residents in each of the watershed

counties should be required to have their systems inspected regularly and pumped out, if necessary. Many of the homeowners in the study area may require financial assistance to address their septic system issues. A publicly-funded program to address failing septic systems could help to reduce *E. coli* loads from the sources in each of the watersheds. Funds from this program could be used to help defray the costs of site inspections and system repairs. Where possible, the funds could also be used to connect individual residences to sewer systems.

Public Outreach to Domestic Animal Owners. An information program to educate residents about the potential for pathogen loads from their pets should be implemented, especially in the urban and suburban communities within the four watersheds. The program should include information about the benefits of cleaning up after pets. Each of the communities in the Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek watersheds should also endeavor to enforce existing codes regarding local leash laws and should establish or increase fines associated with violations of those laws.

Wildlife Population Control Measures. Education programs should be established throughout the watershed communities regarding the contributions that wildlife make to bacterial loadings in the local receiving streams. The education program should describe the conditions that provide desirable habitats for deer, raccoon, and Canadian geese and encourage municipal officials, landowners and farmers to avoid creating those conditions. Reductions in the deer and raccoon population may also be pursued through increases in the number of deer hunting licenses allowed and providing additional financial incentives for the trapping of raccoons in the region.

REFERENCES

- ASAE (American Society of Agricultural Engineers). 1999. *Manure Production and Characteristics* (ASAE D384.1 DEC99), St. Joseph, Michigan.
- Arvin, D. 2004. Personal Communication. United States Geological Survey, Indianapolis, Indiana.
- AVMA (American Veterinary Medical Association). 2002. *U.S. Pet Ownership and Demographics Sourcebook*. Schaumburg, Illinois.
- Baker, C.D. and A. Nelson. 2004. Christopher B. Burke Engineering, Ltd. *Biomonitoring, Water Quality and Habitat Assessment for the Stony Creek Watershed*, Hamilton County, Indiana.
- Delaware County Soil and Water Conservation District (SWCD). 2002-2004. Quarterly Monitoring Reports for the Upper White River Watershed Project.
- Dow, D. 2005. Personal Communication. City of Summitville Town Office, Summitville, Indiana.
- Drapcho, C., J. Beatty, and E. Achberger. 2001. *Water Quality and the Tagipohoa River*. In: Louisiana Agriculture Magazine, Spring 2001, Louisiana State University, Baton Rouge, LA.
- Frankenburger, J. 2004. Personal Communication, Purdue University Agricultural Extension Service, West Lafayette, IN.
- Geldreich, E. E. 1978. *Bacterial populations and indicator concepts in feces, sewage, stormwater and solid wastes*. In *Indicators of Viruses in Water and Food* (Edited by Berg G.). Ann Arbor Science, Ann Arbor, Mich.
- Hanauer, K. 2005. Personal Communication. IDNR District 11 Office, New Castle, Indiana.
- Hardwick, N. 1997. *Lake Sammamish Watershed Water Quality Survey*. King County Water and Land Resources Division, Seattle, Washington. 122 pp.
- Hellweger, F. 1997. *AGREE – DEM Surface Reconditioning System*. University of Texas Center for Research in Water Resources. Austin, Texas. Available via: <http://www.ce.utexas.edu/prof/maidment/gishydro/ferdi/research/agree/agree.html>.
- HGIC (Home and Garden Information Center). 1996. *Residential Fertilizer Use Survey*. University of Maryland Cooperative Extension. College Park, Maryland. Unpublished surveys.
- IDEM (Indiana Department of Environmental Management). 2002. Agreed Order with City of Elwood, Case No. 2002-11411-W. Office of Water Quality.

REFERENCES

- IDEM. 2003. *Fall Creek TMDL Study* (Draft June 26, 2003). Indianapolis, IN. Available via <http://www.in.gov/idem/water/planbr/wqs/tmdl/tmdldocs.html>.
- IDEM. 2003a. *Pleasant Run and Bean Creek TMDL Study* (Draft June 26, 2003). Indianapolis, IN. Available via <http://www.in.gov/idem/water/planbr/wqs/tmdl/tmdldocs.html>.
- IDEM. 2004. 2004 303(d) List of Impaired Waterbodies. Indianapolis, IN. Available via <http://www.in.gov/idem/water/planbr/wqs/303d.html>.
- IDEM. 2004a. Facilities in the National Pollutant Discharge Elimination System with Assigned UTM Coordinates in Indiana. Office of Water Quality, Indianapolis, IN. Available via <http://igs.indiana.edu/>.
- IDEM. 2004b. Confined Feeding Operation Facilities in Indiana. Office of Land Quality, Indianapolis, Indiana. Available via <http://igs.indiana.edu/>.
- IDEM. 2004c. Storm Water General Permit Rule 13 – MS4 Operator Listing. Office of Water Quality. Indianapolis, Indiana. Available at: <http://www.in.gov/idem/water/npdes/permits/wetwthr/storm/ms4oper.html>.
- IDEM. 2005. Personal Communication with M. Dunn regarding CAFOs. Office of Land Quality, Indianapolis, IN.
- IDNR (Indiana Department of Natural Resources). 1999. *1999 Indiana Deer Harvest Summary*. IDNR Division of Fish and Wildlife. Available at: <http://www.in.gov/dnr/fishwild/hunt/deer/deersum2.htm>.
- IDNR . 2000. *2000 Indiana Deer Harvest Summary*. IDNR Division of Fish and Wildlife. Available at: <http://www.in.gov/dnr/fishwild/hunt/deer/deersum.htm>.
- IDNR . 2001. *2001 Indiana Deer Harvest Summary*. IDNR Division of Fish and Wildlife. Available at: <http://www.in.gov/dnr/fishwild/hunt/deer/deersum01.htm>.
- IDNR . 2002. *2002 Indiana Deer Harvest Summary*. IDNR Division of Fish and Wildlife. Available at: <http://www.in.gov/dnr/fishwild/hunt/deer/deersum02.htm>.
- IDNR . 2003. *2003 Indiana Deer Harvest Summary*. IDNR Division of Fish and Wildlife. Available at: <http://www.in.gov/dnr/fishwild/hunt/deer/deersum03.htm>.
- IDNR . 2005. The Raccoon. Life Series Publications. IDNR Division of Fish and Wildlife. Available at: <http://www.in.gov/dnr/fishwild/publications/liferies/raccoon.htm>.
- Martin, A. 2005. Personal Communication, RQAW, Indianapolis, Indiana.

REFERENCES

- McCreedy, C. 1995. *Sustainable Management of a Public Resource: The White-tailed Deer in Indiana* (FNR 153). Purdue University Cooperative Extension Service, West Lafayette, Indiana.
- McNew, F. 2005. Personal Communication. IDNR District 15 Office. Bloomington, Indiana.
- McNulty, B. 2005. Personal Communication. Hamilton County Health Department, Noblesville, Indiana.
- MWPS (Midwest Plan Service). 1993. *Livestock Waste Facilities Handbook* (MWPS-18). Midwest Plan Service, Ames, Iowa.
- NASA (National Aeronautics and Space Administration). 2002. Shuttle Radar Topography Mission Dataset, National Aeronautics and Space Administration, Washington, DC. Available via <http://srtm.usgs.gov/>.
- Newton, G.L., J.C. Johnson, and H.H. Van Horn. 1996. *Dairy Manure Management I. A Nutrient Accounting Approach*, in Animal & Dairy Science Department: 1996 Annual Report, College of Agricultural and Environmental Sciences, The University of Georgia, Athens, GA, pp. 168-173.
- NCDC (National Climatic Data Center). 2004. Precipitation Dataset for Weather Stations. Asheville, NC. Available via <http://www.ncdc.noaa.gov/oa/climate/research.html>.
- NCDC. 2005. Precipitation Dataset for Weather Stations. Asheville, NC. Available via <http://www.ncdc.noaa.gov/oa/climate/research.html>.
- Ormsbee, L. and M. McAlister. 2003. *Kentucky River Watershed Watch Data Collection Effort*. The Kentucky Water Resources Research Institute, Lexington, KY.
- Pierce, L. 2004. Personal Communication. City of Alexandria Wastewater Department, Alexandria, Indiana.
- Plowman, B. 2003. *March 2003 Raccoon Road-Kill Survey*. IDNR Wildlife Management and Research Note #841. December 2003. IDNR. Mitchell, Indiana. Available at: <http://www.state.in.us/dnr/fishwild/publications/notes/03roadkill.pdf>.
- Plowman, B. 2004. *March 2004 Raccoon Road-Kill Survey*. IDNR Wildlife Management and Research Note #868. July 2004. IDNR. Mitchell, Indiana. Available at: <http://www.in.gov/dnr/fishwild/publications/notes/raccoon.pdf>.
- Saunders, W. 2000. *Preparation of DEMs for Use in Environmental Modeling Analysis*. In: Hydrologic and Hydraulic Modeling Support with Geographic Information Systems. ESRI Press, Redlands, California. pp. 29-51.

REFERENCES

- Seal, J. 2004. Personal Communication. City of Frankton Wastewater Department, Frankton, Indiana.
- Shuck, K. 2004. Personal Communication. Poggemeyer Design Group, Indianapolis, Indiana.
- Stedinger, J.R, R.M. Vogel, and E. Foufoula-Georgiou. 1993. *Frequency Analysis of Extreme Events*, in Handbook of Hydrology, D.R. Maidment, Editor-in-Chief, McGraw-Hill, Inc., New York, NY, pp 18-54 – 18-55.
- Stiles, T. 2001. *A Simple Method to Define Bacteria TMDLs in Kansas*, ASIWPCA/ AWCf/WEF TMDL Science Issues Conference: On-Site Program, St. Louis, MO, pp 375-378.
- Stiles, T. and B. Cleland. 2003. *Using Duration Curves in TMDL Development & Implementation Planning*, ASIWPCA “States Helping States” Conference Call, July 2003, Kansas Department of Health and Environment, Topeka, KS, and America’s Clean Water Foundation, Washington, DC.
- Swann, C. 1999. *A Survey of Residential Nutrient Behaviors in the Chesapeake Bay*. Widener-Burrows, Inc. Chesapeake Research Consortium. Center for Watershed Protection. Ellicott City, Maryland. 112 pp.
- Taylor C., J. Yahner, and D. Jones. 1997. *An Evaluation of On-Site Technology in Indiana*. Agronomy and Agricultural and Biological Engineering. Purdue University.
- Thompson, R. 2004. Personal Communication. Hamilton County Surveyor’s Office, Noblesville, Indiana.
- UMD-RRO (University of Michigan-Dearborn Rouge River Observatory). 2003. Cats Indoors! Natural Areas Department, Dearborn, Michigan. Available via http://www.umd.umich.edu/dept/rouge_river/cats.html.
- U.S. Census Bureau. 2000. U.S. Census 2000, Census 2000 Population Compared to 1990: Indiana Places. Available via <http://www.stats.indiana.edu/c2k/c2kframe.html>.
- U.S. Census Bureau. 2000a. U.S. Census 2000, Census 2000 Blockgroup Population Densities: Indiana. Available from <http://igs.indiana.edu/>.
- USDA (U.S. Department of Agriculture). 1997. 1997 Census of Agriculture. U.S. Department of Agriculture. National Agricultural Statistics Service. Available at: <http://www.nass.usda.gov/census/>.
- USDA. 2002. 2002 Census of Agriculture. U.S. Department of Agriculture. National Agricultural Statistics Service. Available at: <http://www.nass.usda.gov/census/>.

REFERENCES

- USDA-NASS (U.S. Department of Agriculture-National Agricultural Statistics Service). 2003. 1:100,000-Scale 2000, 2001, and 2002 Cropland Data Layers for Indiana. Washington, DC. Available from <http://igs.indiana.edu/>.
- USDA-NRCS (U.S. Department of Agriculture-Natural Resources Conservation Service). 2000. Soils_STATSGO_IN: Soil Associations in Indiana. Fort Worth, TX. Available from <http://igs.indiana.edu/>.
- USDA-NRCS. 2002a. *National Planning Procedures Handbook, Amendment 4*. Title 180, Part 600.5. May 2002. USDA-NRCS. Washington, D.C. Available from: http://policy.nrcs.usda.gov/scripts/lpsiis.dll/H/H_180_600.htm.
- USDA-SCS (U.S. Department of Agriculture-Soil Conservation Service). 1973. National Engineering Handbook. Washington, DC.
- USEPA (U.S. Environmental Protection Agency). 1991. *Guidance for Water Quality-based Decisions: The TMDL Process*. EPA 440-4-91-001. Office of Water. U.S. Environmental Protection Agency. Washington, DC. April 1991.
- USEPA. 2000. *Bacterial Indicator Tool User's Guide*. EPA-823-B-01-003. Office of Water. U.S. Environmental Protection Agency. Washington, DC. March 2000.
- USEPA. 2004. *Managing Manure Nutrients at Concentrated Animal Feeding Operations*. EPA-821-B-04-006. Office of Water. U.S. Environmental Protection Agency. Washington, DC. August 2004. Available at: http://www.epa.gov/npdes/pubs/cafo_manure_guidance.pdf.
- USGS (U.S. Geological Survey). 1996. Digital Raster Graphic Topographic Maps. Reston, VA. Available via <http://topomaps.usgs.gov/drg/>.
- USGS. 1999. National Land Cover Dataset. Reston, VA. Available via <http://landcover.usgs.gov/natl/landcover.asp>.
- USGS. 2002. National Hydrography Dataset. Reston, VA. Available via <http://nhd.usgs.gov/data.html>.
- VDEQ (Virginia Department of Environmental Quality). 2002. Fecal Coliform TMDL for Accotink Creek, Fairfax County, Virginia, April 2002. Richmond, Virginia. Available via <http://www.deq.virginia.gov/tmdl/apptmdls/potrvt/accotink.pdf>.
- Washburn, M. 2004. Personal Communication. City of Elwood Division of Wastewater, Elwood, Indiana.

APPENDIX A

WATER QUALITY DATA

Duck Creek Watershed – *E. coli* data

STATION	DATE	DESCRIPTION	SOURCE	E.COLI MF	GEO. MEAN
WWU060-0001	2/20/1996	CR 1300 N, Fairground Rd	IDEM	10	
WWU060-0001	4/22/1996	CR 1300 N, Fairground Rd	IDEM	1200	
WWU060-0001	5/29/1996	CR 1300 N, Fairground Rd	IDEM	40	
WWU060-0001	7/9/1996	CR 1300 N, Fairground Rd	IDEM	280	
WWU060-0001	10/1/1996	CR 1300 N, Fairground Rd	IDEM	100	
WWU060-0001	11/12/1996	CR 1300 N, Fairground Rd	IDEM	470	
WWU060-0001	4/23/2001	CR 1300 N, Fairground Rd	IDEM	340	
WWU060-0001	4/30/2001	CR 1300 N, Fairground Rd	IDEM	250	
WWU060-0001	5/7/2001	CR 1300 N, Fairground Rd	IDEM	200	
WWU060-0001	5/14/2001	CR 1300 N, Fairground Rd	IDEM	150	
WWU060-0001	5/21/2001	CR 1300 N, Fairground Rd	IDEM	330	243
WWU060-0003	2/20/1996	SR 213, D/S Side	IDEM	10	
WWU060-0003	4/22/1996	SR 213, D/S Side	IDEM	1600	
WWU060-0003	5/29/1996	SR 213, D/S Side	IDEM	600	
WWU060-0003	7/9/1996	SR 213, D/S Side	IDEM	40	
WWU060-0003	10/1/1996	SR 213, D/S Side	IDEM	150	
WWU060-0003	11/12/1996	SR 213, D/S Side	IDEM	380	
WWU060-0003	4/23/2001	SR 213, D/S Side	IDEM	480	
WWU060-0003	4/30/2001	SR 213, D/S Side	IDEM	220	
WWU060-0003	5/7/2001	SR 213, D/S Side	IDEM	460	
WWU060-0003	5/14/2001	SR 213, D/S Side	IDEM	440	
WWU060-0003	5/21/2001	SR 213, D/S Side	IDEM	1300	
WWU060-0003	6/4/2001	SR 213, D/S Side	IDEM	921	
WWU060-0003	6/11/2001	SR 213, D/S Side	IDEM	921	
WWU060-0003	6/18/2001	SR 213, D/S Side	IDEM	921	
WWU060-0003	6/25/2001	SR 213, D/S Side	IDEM	517	
WWU060-0003	7/2/2001	SR 213, D/S Side	IDEM	1046	760
WWU060-0009	4/23/2001	Hwy 28	IDEM	410	
WWU060-0009	4/23/2001	Hwy 28	IDEM	340	
WWU060-0009	4/30/2001	Hwy 28	IDEM	25	
WWU060-0009	4/30/2001	Hwy 28	IDEM	100	
WWU060-0009	5/7/2001	Hwy 28	IDEM	2	
WWU060-0009	5/7/2001	Hwy 28	IDEM	180	
WWU060-0009	5/14/2001	Hwy 28	IDEM	1400	
WWU060-0009	5/21/2001	Hwy 28	IDEM	1700	153
WWU060-0010	4/23/2001	CR 1400 N	IDEM	230	
WWU060-0010	4/30/2001	CR 1400 N	IDEM	79	
WWU060-0010	5/7/2001	CR 1400 N	IDEM	450	
WWU060-0010	5/14/2001	CR 1400 N	IDEM	84	
WWU060-0010	5/21/2001	CR 1400 N	IDEM	260	178

Duck Creek Watershed – *E. coli* data

STATION	DATE	DESCRIPTION	SOURCE	E.COLI MF	GEO. MEAN
WWU060-0011	4/23/2001	CR 1400 N	IDEM	520	
WWU060-0011	4/30/2001	CR 1400 N	IDEM	140	
WWU060-0011	5/7/2001	CR 1400 N	IDEM	180	
WWU060-0011	5/14/2001	CR 1400 N	IDEM	290	
WWU060-0011	5/21/2001	CR 1400 N	IDEM	450	280
WWU060-0012	4/23/2001	CR 1400 N	IDEM	2400	
WWU060-0012	4/30/2001	S 9th St (Elwood)	IDEM	240	
WWU060-0012	5/7/2001	S 9th St (Elwood)	IDEM	1100	
WWU060-0012	5/14/2001	S 9th St (Elwood)	IDEM	2000	
WWU060-0012	5/21/2001	S 9th St (Elwood)	IDEM	10000	
WWU060-0012	5/21/2001	S 9th St (Elwood)	IDEM	8200	2125
WWU060-0013	4/23/2001	Elwood WWTP Effluent	IDEM	2400	
WWU060-0013	4/30/2001	Elwood WWTP Effluent	IDEM	730	
WWU060-0013	5/7/2001	Elwood WWTP Effluent	IDEM	2	
WWU060-0013	5/14/2001	Elwood WWTP Effluent	IDEM	10	
WWU060-0013	5/21/2001	Elwood WWTP Effluent	IDEM	9200	200
WWU060-0014	4/23/2001	CR 1050 N	IDEM	1300	
WWU060-0014	4/30/2001	CR 1050 N	IDEM	2	
WWU060-0014	5/7/2001	CR 1050 N	IDEM	2	
WWU060-0014	5/14/2001	CR 1050 N	IDEM	1300	
WWU060-0014	5/21/2001	CR 1050 N	IDEM	3900	121
WWU060-0015	4/23/2001	CR 900 W	IDEM	2000	
WWU060-0015	4/30/2001	CR 900 W	IDEM	220	
WWU060-0015	5/7/2001	CR 900 W	IDEM	2	
WWU060-0015	5/14/2001	CR 900 W	IDEM	2	
WWU060-0015	5/21/2001	CR 900 W	IDEM	4400	95
WWU060-0016	4/23/2001	CR 1000 N	IDEM	1000	
WWU060-0016	4/30/2001	CR 1000 N	IDEM	160	
WWU060-0016	5/7/2001	CR 1000 N	IDEM	2	
WWU060-0016	5/14/2001	CR 1000 N	IDEM	1400	
WWU060-0016	5/21/2001	CR 1000 N	IDEM	2900	265
WWU060-0017	4/23/2001	CR 800 E	IDEM	1600	
WWU060-0017	4/30/2001	CR 800 E	IDEM	2	
WWU060-0017	5/7/2001	CR 800 E	IDEM	200	
WWU060-0017	5/14/2001	CR 800 E	IDEM	660	
WWU060-0017	5/21/2001	CR 800 E	IDEM	410	177
WWU060-0018	4/23/2001	CR 900 N	IDEM	2	
WWU060-0018	4/30/2001	CR 900 N	IDEM	920	
WWU060-0018	5/7/2001	CR 900 N	IDEM	1000	
WWU060-0018	5/14/2001	CR 900 N	IDEM	1200	

Duck Creek Watershed – *E. coli* data

STATION	DATE	DESCRIPTION	SOURCE	E.COLI MF	GEO. MEAN
WWU060-0018	5/21/2001	CR 900 N	IDEM	1700	327
WWU060-0019	4/23/2001	Hayworth Rd (Gunn Rd) (CR 700 E)	IDEM	690	
WWU060-0019	4/30/2001	Hayworth Rd (Gunn Rd) (CR 700 E)	IDEM	920	
WWU060-0019	5/7/2001	Hayworth Rd (Gunn Rd) (CR 700 E)	IDEM	440	
WWU060-0019	5/14/2001	Hayworth Rd (Gunn Rd) (CR 700 E)	IDEM	1300	
WWU060-0019	5/14/2001	Hayworth Rd (Gunn Rd) (CR 700 E)	IDEM	1600	
WWU060-0019	5/21/2001	Hayworth Rd (Gunn Rd) (CR 700 E)	IDEM	1100	985
WWU060-0020	4/23/2001	E 246th St, (CR 300 N)	IDEM	870	
WWU060-0020	4/30/2001	E 246th St, (CR 300 N)	IDEM	240	
WWU060-0020	5/7/2001	E 246th St, (CR 300 N)	IDEM	520	
WWU060-0020	5/14/2001	E 246th St, (CR 300 N)	IDEM	870	
WWU060-0020	5/21/2001	E 246th St, (CR 300 N)	IDEM	3300	792
WWU060-0021	4/23/2001	Henry Gunn Rd	IDEM	2400	
WWU060-0021	4/30/2001	Henry Gunn Rd	IDEM	2400	
WWU060-0021	5/7/2001	Henry Gunn Rd	IDEM	370	
WWU060-0021	5/14/2001	Henry Gunn Rd	IDEM	5500	
WWU060-0021	5/21/2001	Henry Gunn Rd	IDEM	4600	2220
WWU060-0022	8/6/1996	20th St	IDEM	390	

Pipe Creek Watershed – *E. coli* data

STATION	DATE	DESCRIPTION	SOURCE	E.COLI MF	GEO. MEAN
WWU050-0003	2/20/1996	SR 13	1996 Synoptic	20	
WWU050-0003	4/24/1996	SR 13	1996 Synoptic	2800	
WWU050-0003	5/31/1996	SR 13	1996 Synoptic	600	
WWU050-0003	7/9/1996	SR 13	1996 Synoptic	330	
WWU050-0003	10/2/1996	SR 13	1996 Synoptic	420	
WWU050-0003	11/14/1996	SR 13	1996 Synoptic	4800	
WWU050-0003	6/4/2001	SR 13	2001 W Fk White River in Hamilton Co Assessment	770	
WWU050-0003	6/5/2001	SR 13	2001 Pipe Creek TMDL	649	
WWU050-0003	6/11/2001	SR 13	2001 W Fk White River in Hamilton Co Assessment	816	
WWU050-0003	6/12/2001	SR 13	2001 Pipe Creek TMDL	1553	
WWU050-0003	6/18/2001	SR 13	2001 W Fk White River in Hamilton Co Assessment	866	
WWU050-0003	6/19/2001	SR 13	2001 Pipe Creek TMDL	727	
WWU050-0003	6/25/2001	SR 13	2001 W Fk White River in Hamilton Co Assessment	727	
WWU050-0003	6/26/2001	SR 13	2001 Pipe Creek TMDL	579	
WWU050-0003	6/26/2001	SR 13	2001 Pipe Creek TMDL	649	
WWU050-0003	7/2/2001	SR 13	2001 WFWR in Hamilton Co	517	
WWU050-0003	7/3/2001	SR 13	2001 Pipe Creek TMDL	308	692
WWU050-0005	6/5/2001	CR 500 W , NE of Frankton (Madison Co)	2001 Pipe Creek TMDL	2	
WWU050-0005	6/12/2001	CR 500 W , NE of Frankton (Madison Co)	2001 Pipe Creek TMDL	14136	
WWU050-0005	6/19/2001	CR 500 W , NE of Frankton (Madison Co)	2001 Pipe Creek TMDL	2282	
WWU050-0005	6/26/2001	CR 500 W , NE of Frankton (Madison Co)	2001 Pipe Creek TMDL	1414	
WWU050-0005	7/3/2001	CR 500 W , NE of Frankton (Madison Co)	2001 Pipe Creek TMDL	461	531
WWU050-0012	8/6/1996	CR 200 W	1996 Watershed	400	
WWU050-0013	6/5/2001	CR 200 W	2001 Pipe Creek TMDL	2	
WWU050-0013	6/12/2001	CR 200 W	2001 Pipe Creek TMDL	179	
WWU050-0013	6/19/2001	CR 200 W	2001 Pipe Creek TMDL	2142	
WWU050-0013	6/26/2001	CR 200 W	2001 Pipe Creek TMDL	1414	
WWU050-0013	7/3/2001	CR 200 W	2001 Pipe Creek TMDL	365	
WWU050-0013	7/3/2001	CR 200 W	2001 Pipe Creek TMDL	488	240
WWU050-0014	6/5/2001	CR 200 W	2001 Pipe Creek TMDL	2	
WWU050-0014	6/12/2001	CR 200 W	2001 Pipe Creek TMDL	12033	
WWU050-0014	6/19/2001	CR 200 W	2001 Pipe Creek TMDL	1120	
WWU050-0014	6/19/2001	CR 200 W	2001 Pipe Creek TMDL	1300	
WWU050-0014	6/26/2001	CR 200 W	2001 Pipe Creek TMDL	687	
WWU050-0014	7/3/2001	CR 200 W	2001 Pipe Creek TMDL	291	437
WWU050-0015	6/5/2001	CR 1100 N (Bethel Rd)	2001 Pipe Creek TMDL	770	
WWU050-0015	6/12/2001	CR 1100 N (Bethel Rd)	2001 Pipe Creek TMDL	1553	
WWU050-0015	6/19/2001	CR 1100 N (Bethel Rd)	2001 Pipe Creek TMDL	517	
WWU050-0015	6/26/2001	CR 1100 N (Bethel Rd)	2001 Pipe Creek TMDL	461	

Pipe Creek Watershed – *E. coli* data

STATION	DATE	DESCRIPTION	SOURCE	E.COLI MF	GEO. MEAN
WWU050-0015	7/3/2001	CR 1100 N (Bethel Rd)	2001 Pipe Creek TMDL	816	638
WWU050-0016	6/5/2001	CR 1400 N	2001 Pipe Creek TMDL	727	
WWU050-0016	6/12/2001	CR 1400 N	2001 Pipe Creek TMDL	387	
WWU050-0016	6/19/2001	CR 1400 N	2001 Pipe Creek TMDL	461	
WWU050-0016	6/26/2001	CR 1400 N	2001 Pipe Creek TMDL	1046	
WWU050-0016	7/3/2001	CR 1400 N	2001 Pipe Creek TMDL	1120	686
WWU050-0017	6/5/2001	CR 900 N	2001 Pipe Creek TMDL	1120	
WWU050-0017	6/12/2001	CR 900 N	2001 Pipe Creek TMDL	2	
WWU050-0017	6/12/2001	CR 900 N	2001 Pipe Creek TMDL	2	
WWU050-0017	6/19/2001	CR 900 N	2001 Pipe Creek TMDL	579	
WWU050-0017	6/26/2001	CR 900 N	2001 Pipe Creek TMDL	2014	
WWU050-0017	7/3/2001	CR 900 N	2001 Pipe Creek TMDL	167	98
WWU050-0018	6/5/2001	CR 600 W	2001 Pipe Creek TMDL	435	
WWU050-0018	6/12/2001	CR 600 W	2001 Pipe Creek TMDL	1203	
WWU050-0018	6/19/2001	CR 600 W	2001 Pipe Creek TMDL	2419	
WWU050-0018	6/26/2001	CR 600 W	2001 Pipe Creek TMDL	1733	
WWU050-0018	7/3/2001	CR 600 W	2001 Pipe Creek TMDL	1733	1306

Killbuck Creek Watershed – *E. coli* data

STATION	DATE	DESCRIPTION	SOURCE	E.COLI MF	GEO. MEAN
WWU040-0001	4/24/2001	SR 9 Bridge, NE Side of Anderson	2001 Killbuck Creek TMDL	96	
WWU040-0001	5/1/2001	SR 9 Bridge, NE Side of Anderson	2001 Killbuck Creek TMDL	160	
WWU040-0001	5/8/2001	SR 9 Bridge, NE Side of Anderson	2001 Killbuck Creek TMDL	770	
WWU040-0001	5/15/2001	SR 9 Bridge, NE Side of Anderson	2001 Killbuck Creek TMDL	100	
WWU040-0001	5/22/2001	SR 9 Bridge, NE Side of Anderson	2001 Killbuck Creek TMDL	280	266
WWU040-0012	4/24/2001	Grand Ave, Anderson	2001 WFWR in Madison County	100	
WWU040-0012	5/1/2001	Grand Ave, Anderson	2001 WFWR in Madison County	170	
WWU040-0012	5/8/2001	Grand Ave, Anderson	2001 WFWR in Madison County	1000	
WWU040-0012	5/15/2001	Grand Ave, Anderson	2001 WFWR in Madison County	280	
WWU040-0012	5/22/2001	Grand Ave, Anderson	2001 WFWR in Madison County	210	251
WWU040-0018	4/24/2001	Broadway St (Jackson St)	2001 Killbuck Creek TMDL	96	
WWU040-0018	5/1/2001	Broadway St (Jackson St)	2001 Killbuck Creek TMDL	200	
WWU040-0018	5/8/2001	Broadway St (Jackson St)	2001 Killbuck Creek TMDL	610	
WWU040-0018	5/15/2001	Broadway St (Jackson St)	2001 Killbuck Creek TMDL	200	
WWU040-0018	5/15/2001	Broadway St (Jackson St)	2001 Killbuck Creek TMDL	210	218
WWU040-0018	5/22/2001	Broadway St (Jackson St)	2001 Killbuck Creek TMDL	300	
WWU040-0018	5/22/2001	Broadway St (Jackson St)	2001 Killbuck Creek TMDL	290	
WWU040-0019	4/24/2001	CR 400 N	2001 Killbuck Creek TMDL	340	
WWU040-0019	5/1/2001	CR 400 N	2001 Killbuck Creek TMDL	490	
WWU040-0019	5/8/2001	CR 400 N	2001 Killbuck Creek TMDL	8700	
WWU040-0019	5/15/2001	CR 400 N	2001 Killbuck Creek TMDL	580	
WWU040-0019	5/22/2001	CR 400 N	2001 Killbuck Creek TMDL	330	774
WWU040-0020	4/24/2001	CR 400 N	2001 Killbuck Creek TMDL	210	
WWU040-0020	5/1/2001	CR 400 N	2001 Killbuck Creek TMDL	110	
WWU040-0020	5/8/2001	CR 400 N	2001 Killbuck Creek TMDL	2000	
WWU040-0020	5/15/2001	CR 400 N	2001 Killbuck Creek TMDL	29	
WWU040-0020	5/22/2001	CR 400 N	2001 Killbuck Creek TMDL	240	200
WWU040-0021	4/24/2001	CR 425 E	2001 Killbuck Creek TMDL	260	
WWU040-0021	4/24/2001	CR 425 E	2001 Killbuck Creek TMDL	310	
WWU040-0021	5/1/2001	CR 425 E	2001 Killbuck Creek TMDL	170	
WWU040-0021	5/8/2001	CR 425 E	2001 Killbuck Creek TMDL	2400	
WWU040-0021	5/15/2001	CR 425 E	2001 Killbuck Creek TMDL	870	
WWU040-0021	5/22/2001	CR 425 E	2001 Killbuck Creek TMDL	400	475
WWU040-0022	4/24/2001	SR 332	2001 Killbuck Creek TMDL	520	
WWU040-0022	5/1/2001	SR 332	2001 Killbuck Creek TMDL	370	
WWU040-0022	5/8/2001	SR 332	2001 Killbuck Creek TMDL	2400	
WWU040-0022	5/15/2001	SR 332	2001 Killbuck Creek TMDL	870	
WWU040-0022	5/22/2001	SR 332	2001 Killbuck Creek TMDL	550	739
WWU040-0023	4/24/2001	NCR 925 W	2001 Killbuck Creek TMDL	580	
WWU040-0023	5/1/2001	NCR 925 W	2001 Killbuck Creek TMDL	490	

Killbuck Creek Watershed – *E. coli* data

STATION	DATE	DESCRIPTION	SOURCE	E.COLI MF	GEO. MEAN
WWU040-0023	5/8/2001	NCR 925 W	2001 Killbuck Creek TMDL	2	
WWU040-0023	5/15/2001	NCR 925 W	2001 Killbuck Creek TMDL	730	
WWU040-0023	5/22/2001	NCR 925 W	2001 Killbuck Creek TMDL	440	179
WWU040-0024	4/24/2001	CR 750 W	2001 Killbuck Creek TMDL	690	
WWU040-0024	5/1/2001	CR 750 W	2001 Killbuck Creek TMDL	2400	
WWU040-0024	5/8/2001	CR 750 W	2001 Killbuck Creek TMDL	2	
WWU040-0024	5/15/2001	CR 750 W	2001 Killbuck Creek TMDL	2	
WWU040-0024	5/22/2001	CR 750 W	2001 Killbuck Creek TMDL	330	74
WWU040-0025	4/24/2001	CR 700 W	2001 Killbuck Creek TMDL	410	
WWU040-0025	5/1/2001	CR 700 W	2001 Killbuck Creek TMDL	170	
WWU040-0025	5/1/2001	CR 700 W	2001 Killbuck Creek TMDL	110	
WWU040-0025	5/8/2001	CR 700 W	2001 Killbuck Creek TMDL	580	
WWU040-0025	5/15/2001	CR 700 W	2001 Killbuck Creek TMDL	410	
WWU040-0025	5/22/2001	CR 700 W	2001 Killbuck Creek TMDL	520	313
WWU040-0026	4/24/2001	SR 28 / US 35	2001 Killbuck Creek TMDL	2000	
WWU040-0026	5/1/2001	SR 28 / US 35	2001 Killbuck Creek TMDL	310	
WWU040-0026	5/8/2001	SR 28 / US 35	2001 Killbuck Creek TMDL	580	
WWU040-0026	5/15/2001	SR 28 / US 35	2001 Killbuck Creek TMDL	390	
WWU040-0026	5/22/2001	SR 28 / US 35	2001 Killbuck Creek TMDL	260	516
WWU040-0027	4/24/2001	SR 28 / US 35	2001 Killbuck Creek TMDL	2	
WWU040-0027	5/1/2001	SR 28 / US 35	2001 Killbuck Creek TMDL	2	
WWU040-0027	5/8/2001	SR 28 / US 35	2001 Killbuck Creek TMDL	8200	
WWU040-0027	5/8/2001	SR 28 / US 35	2001 Killbuck Creek TMDL	1100	
WWU040-0027	5/15/2001	SR 28 / US 35	2001 Killbuck Creek TMDL	550	
WWU040-0027	5/22/2001	SR 28 / US 35	2001 Killbuck Creek TMDL	180	124
WWU040-0028	4/24/2001	CR 200 W	2001 Killbuck Creek TMDL	190	
WWU040-0028	5/1/2001	CR 200 W	2001 Killbuck Creek TMDL	11	
WWU040-0028	5/8/2001	CR 200 W	2001 Killbuck Creek TMDL	91	
WWU040-0028	5/15/2001	CR 200 W	2001 Killbuck Creek TMDL	54	
WWU040-0028	5/22/2001	CR 200 W	2001 Killbuck Creek TMDL	160	70
K-1	7/23/2002	Wheeling Avenue Bridge	Upper White River Watershed Project	5500	
K-1	10/17/2002	Wheeling Avenue Bridge	Upper White River Watershed Project	1130	
K-1	5/1/2003	Wheeling Avenue Bridge	Upper White River Watershed Project	640	
K-1	5/5/2003	Wheeling Avenue Bridge	Upper White River Watershed Project	9600	
K-1	5/8/2003	Wheeling Avenue Bridge	Upper White River Watershed Project	1070	
K-1	5/15/2003	Wheeling Avenue Bridge	Upper White River Watershed Project	11000	
K-1	5/22/2003	Wheeling Avenue Bridge	Upper White River Watershed Project	762	
K-1	5/29/2003	Wheeling Avenue Bridge	Upper White River Watershed Project	3900	
K-1	7/23/2003	Wheeling Avenue Bridge	Upper White River Watershed Project	772	
K-1	9/3/2003	Wheeling Avenue Bridge	Upper White River Watershed Project	6700	

Killbuck Creek Watershed – *E. coli* data

STATION	DATE	DESCRIPTION	SOURCE	E.COLI MF	GEO. MEAN
K-1	10/14/2003	Wheeling Avenue Bridge	Upper White River Watershed Project	833	
K-1	4/29/2004	Wheeling Avenue Bridge	Upper White River Watershed Project	146	
K-2	7/23/2002	SR 28 Bridge	Upper White River Watershed Project	1110	
K-2	10/15/2002	SR 28 Bridge	Upper White River Watershed Project	470	
K-2	5/1/2003	SR 28 Bridge	Upper White River Watershed Project	1370	
K-2	5/5/2003	SR 28 Bridge	Upper White River Watershed Project	11300	
K-2	5/8/2003	SR 28 Bridge	Upper White River Watershed Project	2640	
K-2	5/22/2003	SR 28 Bridge	Upper White River Watershed Project	1270	
K-2	5/29/2003	SR 28 Bridge	Upper White River Watershed Project	5700	
K-2	7/23/2003	SR 28 Bridge	Upper White River Watershed Project	667	
K-2	9/3/2003	SR 28 Bridge	Upper White River Watershed Project	10700	
K-2	10/14/2003	SR 28 Bridge	Upper White River Watershed Project	1300	
K-2	4/29/2004	SR 28 Bridge	Upper White River Watershed Project	152	
K-3	7/23/2002	CR 25 West Bridge	Upper White River Watershed Project	1060	
K-3	10/15/2002	CR 25 West Bridge	Upper White River Watershed Project	1100	
K-3	5/1/2003	CR 25 West Bridge	Upper White River Watershed Project	1630	
K-3	5/5/2003	CR 25 West Bridge	Upper White River Watershed Project	4540	
K-3	5/8/2003	CR 25 West Bridge	Upper White River Watershed Project	2400	

Stony Creek Watershed – E. coli data

STATION	DATE	DESCRIPTION	SOURCE	E.COLI MF	GEO. MEAN
WWU070-0002	2/22/1996	Cumberland Rd, Gaging Station	IDEM	1	
WWU070-0002	4/24/1996	Cumberland Rd, Gaging Station	IDEM	1600	
WWU070-0002	6/4/1996	Cumberland Rd, Gaging Station	IDEM	220	
WWU070-0002	7/11/1996	Cumberland Rd, Gaging Station	IDEM	170	
WWU070-0002	10/3/1996	Cumberland Rd, Gaging Station	IDEM	800	
WWU070-0002	11/14/1996	Cumberland Rd, Gaging Station	IDEM	70	
WWU070-0002	6/5/2001	Cumberland Rd, Gaging Station	IDEM	770	
WWU070-0002	6/12/2001	Cumberland Rd, Gaging Station	IDEM	650	
WWU070-0002	6/19/2001	Cumberland Rd, Gaging Station	IDEM	820	
WWU070-0002	6/26/2001	Cumberland Rd, Gaging Station	IDEM	610	
WWU070-0002	7/3/2001	Cumberland Rd, Gaging Station	IDEM	310	600
WWU070-0016	6/4/2001	Allisonville Road	IDEM	1046	
WWU070-0016	6/5/2001	Allisonville Road	IDEM	770	
WWU070-0016	6/11/2001	Allisonville Road	IDEM	148	
WWU070-0016	6/12/2001	Allisonville Road	IDEM	370	
WWU070-0016	6/18/2001	Allisonville Road	IDEM	727	
WWU070-0016	6/18/2001	Allisonville Road	IDEM	770	
WWU070-0016	6/19/2001	Allisonville Road	IDEM	440	
WWU070-0016	6/25/2001	Allisonville Road	IDEM	4	
WWU070-0016	6/26/2001	Allisonville Road	IDEM	410	
WWU070-0016	7/2/2001	Allisonville Road	IDEM	816	
WWU070-0016	7/3/2001	Allisonville Road	IDEM	410	
WWU070-0016	7/3/2001	Allisonville Road	IDEM	410	308
WWU070-0018	6/5/2001	166th St. Noblesville	IDEM	280	
WWU070-0018	6/12/2001	166th St. Noblesville	IDEM	520	
WWU070-0018	6/19/2001	166th St. Noblesville	IDEM	270	
WWU070-0018	6/26/2001	166th St. Noblesville	IDEM	920	
WWU070-0018	7/3/2001	166th St. Noblesville	IDEM	730	483
WWU070-0019	6/5/2001	Union Chapel Rd	IDEM	2400	
WWU070-0019	6/12/2001	Union Chapel Rd	IDEM	1100	
WWU070-0019	6/19/2001	Union Chapel Rd	IDEM	1200	
WWU070-0019	6/26/2001	Union Chapel Rd	IDEM	310	
WWU070-0019	7/3/2001	Union Chapel Rd	IDEM	820	958
WWU070-0020	6/5/2001	166th St.	IDEM	650	
WWU070-0020	6/12/2001	166th St.	IDEM	240	
WWU070-0020	6/19/2001	166th St.	IDEM	2000	
WWU070-0020	6/26/2001	166th St.	IDEM	580	
WWU070-0020	7/3/2001	166th St.	IDEM	1200	737
WWU070-0021	6/5/2001	Private Drive off SR 38	IDEM	2000	
WWU070-0021	6/12/2001	Private Drive off SR 38	IDEM	1600	

Stony Creek Watershed – E. coli data

STATION	DATE	DESCRIPTION	SOURCE	E.COLI MF	GEO. MEAN
WWU070-0021	6/19/2001	Private Drive off SR 38	IDEM	920	
WWU070-0021	6/26/2001	Private Drive off SR 38	IDEM	870	
WWU070-0021	7/3/2001	Private Drive off SR 38	IDEM	1100	1230
WWU070-0022	6/5/2001	SR 38	IDEM	1400	
WWU070-0022	6/5/2001	SR 38	IDEM	2000	
WWU070-0022	6/12/2001	SR 38	IDEM	770	
WWU070-0022	6/19/2001	SR 38	IDEM	1400	
WWU070-0022	6/26/2001	SR 38	IDEM	2000	1433
WWU070-0024	6/5/2001	E. 196th Street near Mystic Road	IDEM	1200	
WWU070-0024	6/12/2001	E. 196th Street near Mystic Road	IDEM	2000	
WWU070-0024	6/19/2001	E. 196th Street near Mystic Road	IDEM	1100	
WWU070-0024	6/26/2001	E. 196th Street near Mystic Road	IDEM	920	
WWU070-0024	7/3/2001	E. 196th Street near Mystic Road	IDEM	690	1109
WWU070-0025	6/5/2001	E. 196th St. near Mystic Road	IDEM	340	
WWU070-0025	6/12/2001	E. 196th St. near Mystic Road	IDEM	820	
WWU070-0025	6/12/2001	E. 196th St. near Mystic Road	IDEM	770	
WWU070-0025	6/19/2001	E. 196th St. near Mystic Road	IDEM	610	
WWU070-0025	6/26/2001	E. 196th St. near Mystic Road	IDEM	770	
WWU070-0025	7/3/2001	E. 196th St. near Mystic Road	IDEM	1300	713
WWU070-0026	6/5/2001	Not Listed	IDEM	1200	
WWU070-0026	6/12/2001	Not Listed	IDEM	2	
WWU070-0026	6/19/2001	Not Listed	IDEM	1400	
WWU070-0026	6/26/2001	Not Listed	IDEM	770	
WWU070-0026	7/3/2001	Not Listed	IDEM	870	
WWU070-0026	7/3/2001	Not Listed	IDEM	870	354
WWU070-0027	6/5/2001	Gravel Road off E. 196th Street	IDEM	730	
WWU070-0027	6/12/2001	Gravel Road off E. 196th Street	IDEM	870	
WWU070-0027	6/19/2001	Gravel Road off E. 196th Street	IDEM	2	
WWU070-0027	6/19/2001	Gravel Road off E. 196th Street	IDEM	2	
WWU070-0027	6/26/2001	Gravel Road off E. 196th Street	IDEM	870	
WWU070-0027	7/3/2001	Gravel Road off E. 196th Street	IDEM	2	41
WWU070-0028	6/5/2001	E. 206th Street near Durbin Rd.	IDEM	2400	
WWU070-0028	6/12/2001	E. 206th Street near Durbin Rd.	IDEM	730	
WWU070-0028	6/19/2001	E. 206th Street near Durbin Rd.	IDEM	2	
WWU070-0028	6/26/2001	E. 206th Street near Durbin Rd.	IDEM	2400	
WWU070-0028	7/3/2001	E. 206th Street near Durbin Rd.	IDEM	1000	
WWU070-0028	7/3/2001	E. 206th Street near Durbin Rd.	IDEM	980	449
WWU070-0029	6/5/2001	Cyntheanne Road	IDEM	1200	
WWU070-0029	6/12/2001	Cyntheanne Road	IDEM	820	
WWU070-0029	6/19/2001	Cyntheanne Road	IDEM	1300	

Stony Creek Watershed – E. coli data

STATION	DATE	DESCRIPTION	SOURCE	E.COLI MF	GEO. MEAN
WWU070-0029	6/26/2001	Cyntheanne Road	IDEM	1700	
WWU070-0029	7/3/2001	Cyntheanne Road	IDEM	410	977
WWU070-0030	6/5/2001	CR 1000 W.	IDEM	1000	
WWU070-0030	6/12/2001	CR 1000 W.	IDEM	1100	
WWU070-0030	6/19/2001	CR 1000 W.	IDEM	2	
WWU070-0030	6/26/2001	CR 1000 W.	IDEM	2400	
WWU070-0030	6/26/2001	CR 1000 W.	IDEM	2400	
WWU070-0030	7/3/2001	CR 1000 W.	IDEM	2	120
WWU070-0031	6/5/2001	SR 132/13	IDEM	610	
WWU070-0031	6/12/2001	SR 132/13	IDEM	2	
WWU070-0031	6/19/2001	SR 132/13	IDEM	920	
WWU070-0031	6/26/2001	SR 132/13	IDEM	2400	
WWU070-0031	7/3/2001	SR 132/13	IDEM	1300	323
WWU070-0032	6/5/2001	CR 925 West	IDEM	410	
WWU070-0032	6/12/2001	CR 925 West	IDEM	820	
WWU070-0032	6/19/2001	CR 925 West	IDEM	820	
WWU070-0032	6/26/2001	CR 925 West	IDEM	920	
WWU070-0032	7/3/2001	CR 925 West	IDEM	2400	905
WWU070-0033	6/5/2001	CR 825 W	IDEM	730	
WWU070-0033	6/12/2001	CR 825 W	IDEM	770	
WWU070-0033	6/19/2001	CR 825 W	IDEM	980	
WWU070-0033	6/26/2001	CR 825 W	IDEM	920	
WWU070-0033	7/3/2001	CR 825 W	IDEM	770	828
WWU070-0034	6/5/2001	CR 650 W	IDEM	580	
WWU070-0034	6/12/2001	CR 650 W	IDEM	490	
WWU070-0034	6/19/2001	CR 650 W	IDEM	520	
WWU070-0034	7/3/2001	CR 650 W	IDEM	250	491
1	5/13/2003	Atlantic Road	Stony Watershed WQ Assessment	65*	
1	6/27/2003	Atlantic Road	Stony Watershed WQ Assessment	1996*	
1	10/3/2003	Atlantic Road	Stony Watershed WQ Assessment	1109*	
2	5/13/2003	Wm. Lock Ditch	Stony Watershed WQ Assessment	146*	
2	6/27/2003	Wm. Lock Ditch	Stony Watershed WQ Assessment	168*	
2	10/3/2003	Wm. Lock Ditch	Stony Watershed WQ Assessment	157*	
3	5/13/2003	196 th Street and Mystic Road	Stony Watershed WQ Assessment	230*	
3	6/27/2003	196 th Street and Mystic Road	Stony Watershed WQ Assessment	283*	
3	10/3/2003	196 th Street and Mystic Road	Stony Watershed WQ Assessment	110*	
4	5/13/2003	Highway 38	Stony Watershed WQ Assessment	212*	
4	6/27/2003	Highway 38	Stony Watershed WQ Assessment	662*	
4	10/3/2003	Highway 38	Stony Watershed WQ Assessment	180*	
5	5/13/2003	166 Street near Boden Road	Stony Watershed WQ Assessment	156*	

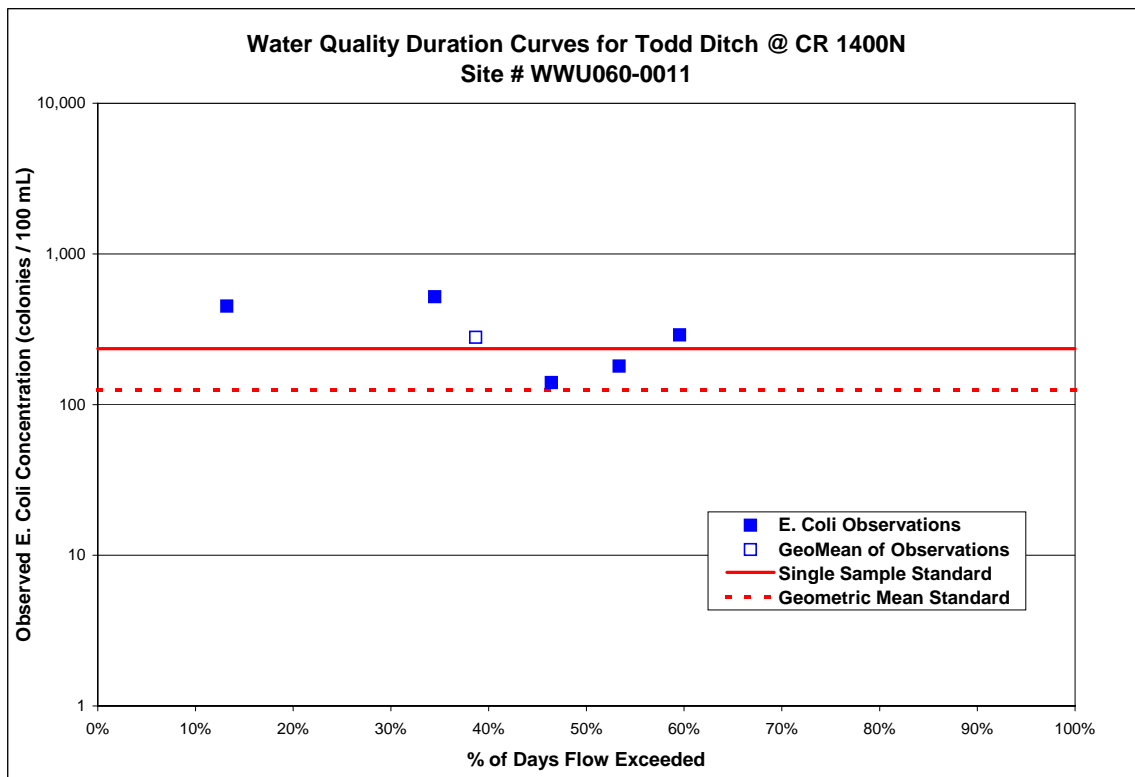
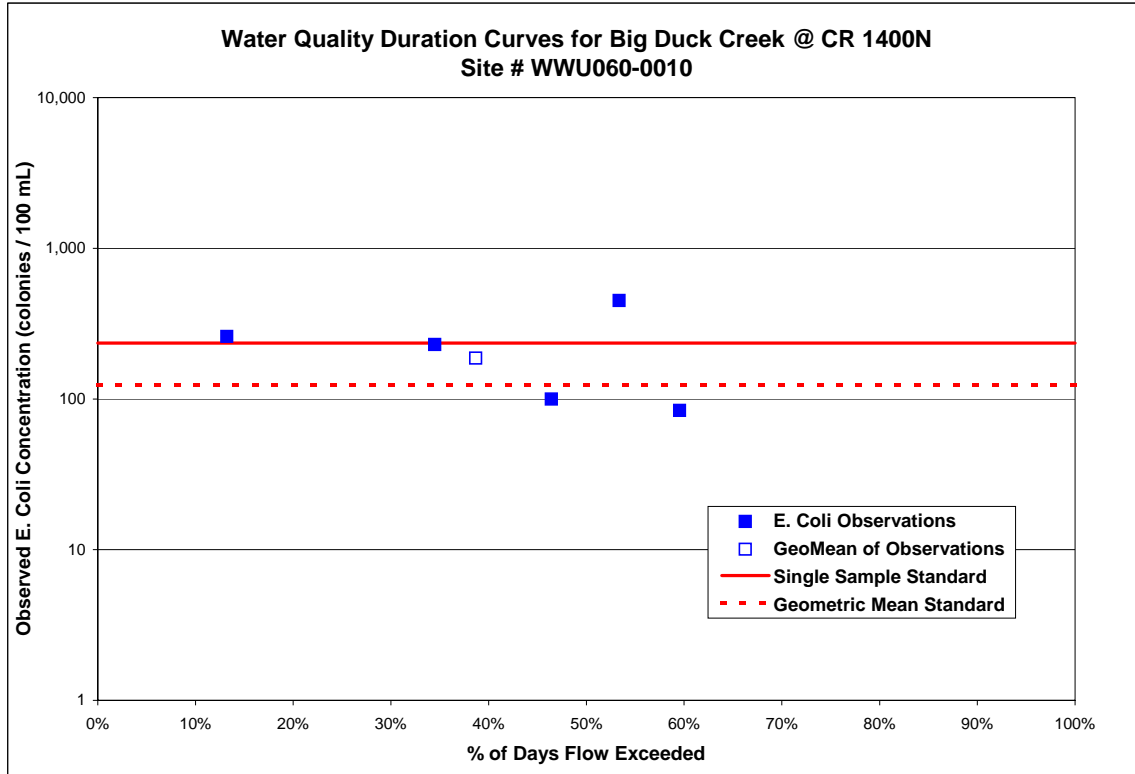
Stony Creek Watershed – *E. coli* data

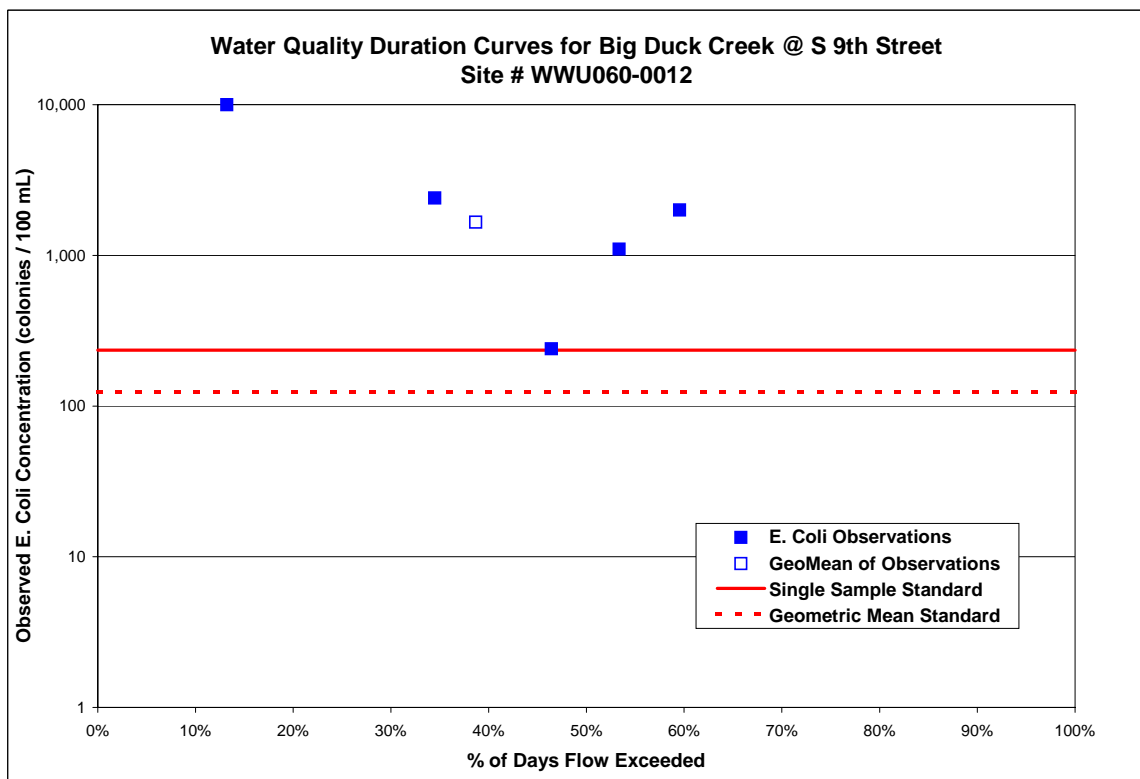
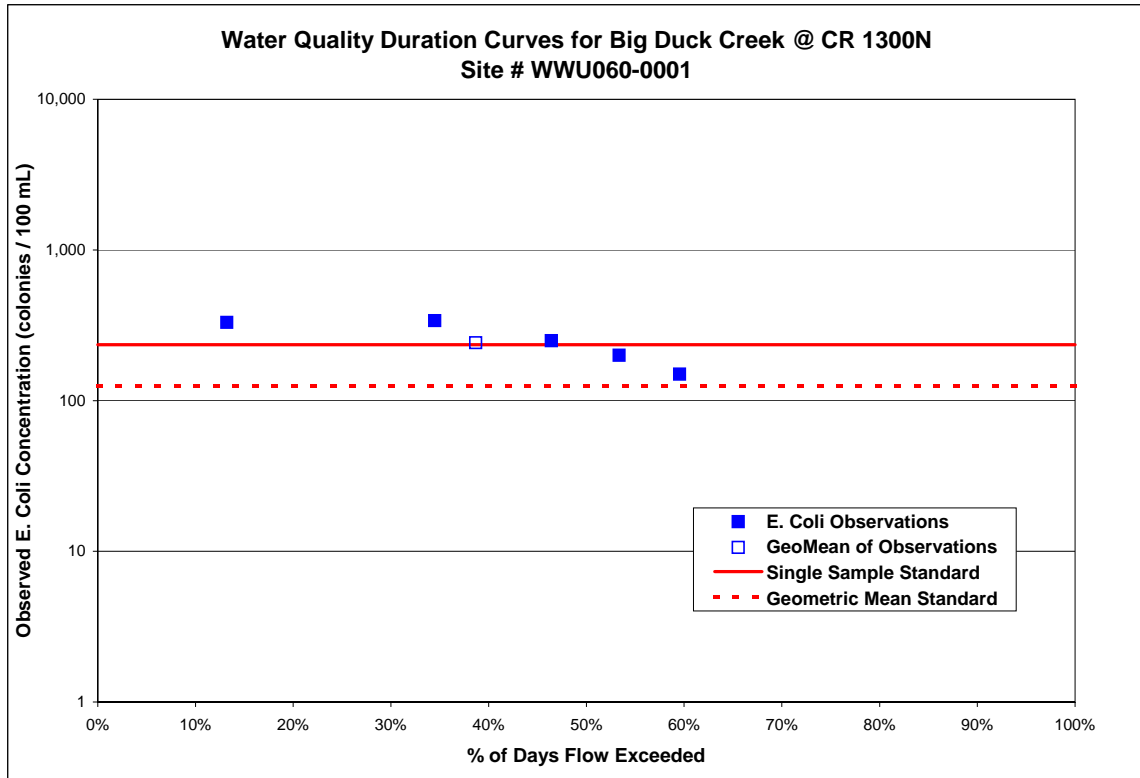
STATION	DATE	DESCRIPTION	SOURCE	E.COLI MF	GEO. MEAN
5	6/27/2003	166 Street near Boden Road	Stony Watershed WQ Assessment	1996*	
5	10/3/2003	166 Street near Boden Road	Stony Watershed WQ Assessment	132*	
6	5/13/2003	Cumberland Road	Stony Watershed WQ Assessment	247*	
6	6/27/2003	Cumberland Road	Stony Watershed WQ Assessment	290*	
6	10/3/2003	Cumberland Road	Stony Watershed WQ Assessment	327*	
7	5/13/2003	Greenfield Road	Stony Watershed WQ Assessment	262*	
7	6/27/2003	Greenfield Road	Stony Watershed WQ Assessment	174*	
7	10/3/2003	Greenfield Road	Stony Watershed WQ Assessment	236*	
8	5/13/2003	Allisonville Road	Stony Watershed WQ Assessment	1364*	
8	6/27/2003	Allisonville Road	Stony Watershed WQ Assessment	236*	
8	10/3/2003	Allisonville Road	Stony Watershed WQ Assessment	200*	
2A	5/13/2003	Pilgrim Road	Stony Watershed WQ Assessment	262*	
2A	6/27/2003	Pilgrim Road	Stony Watershed WQ Assessment	2746*	
2A	10/3/2003	Pilgrim Road	Stony Watershed WQ Assessment	158*	

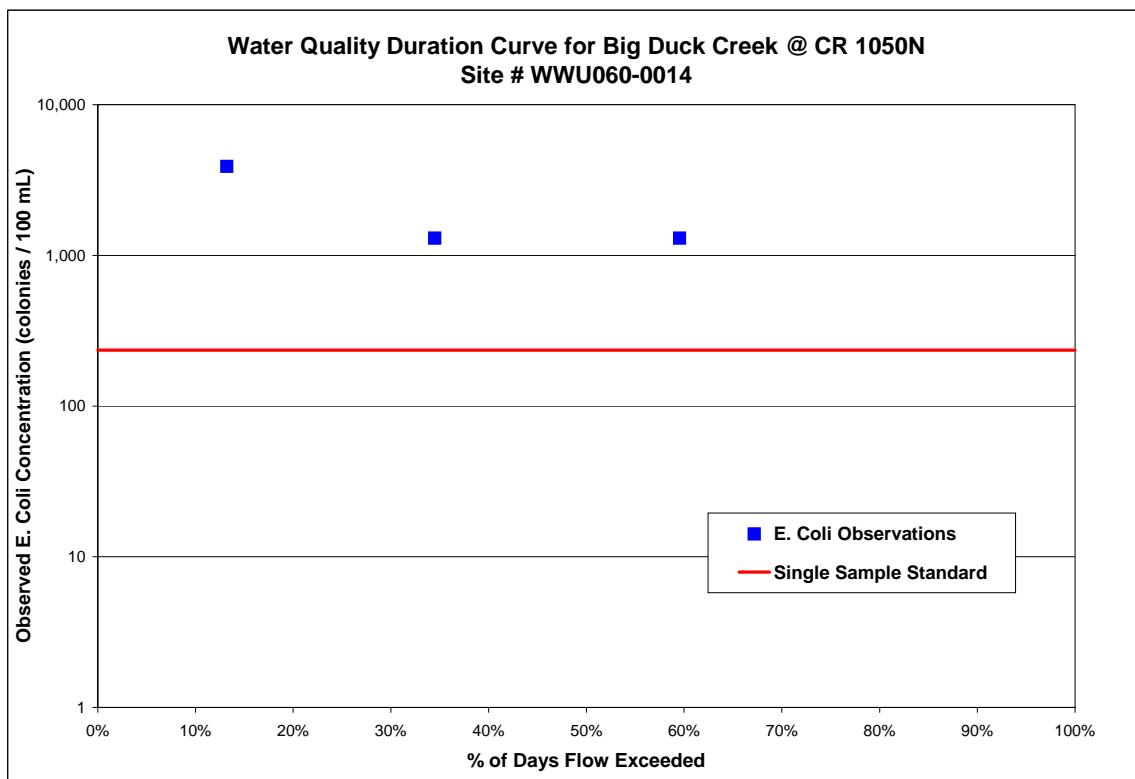
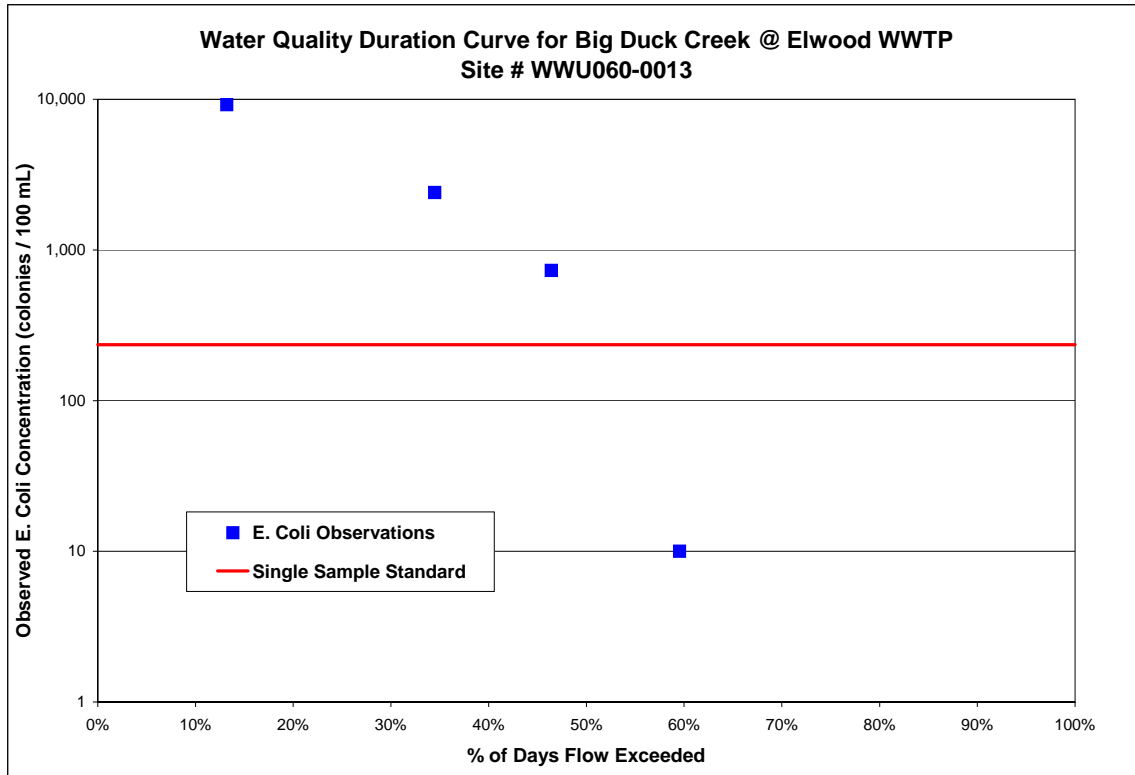
APPENDIX B

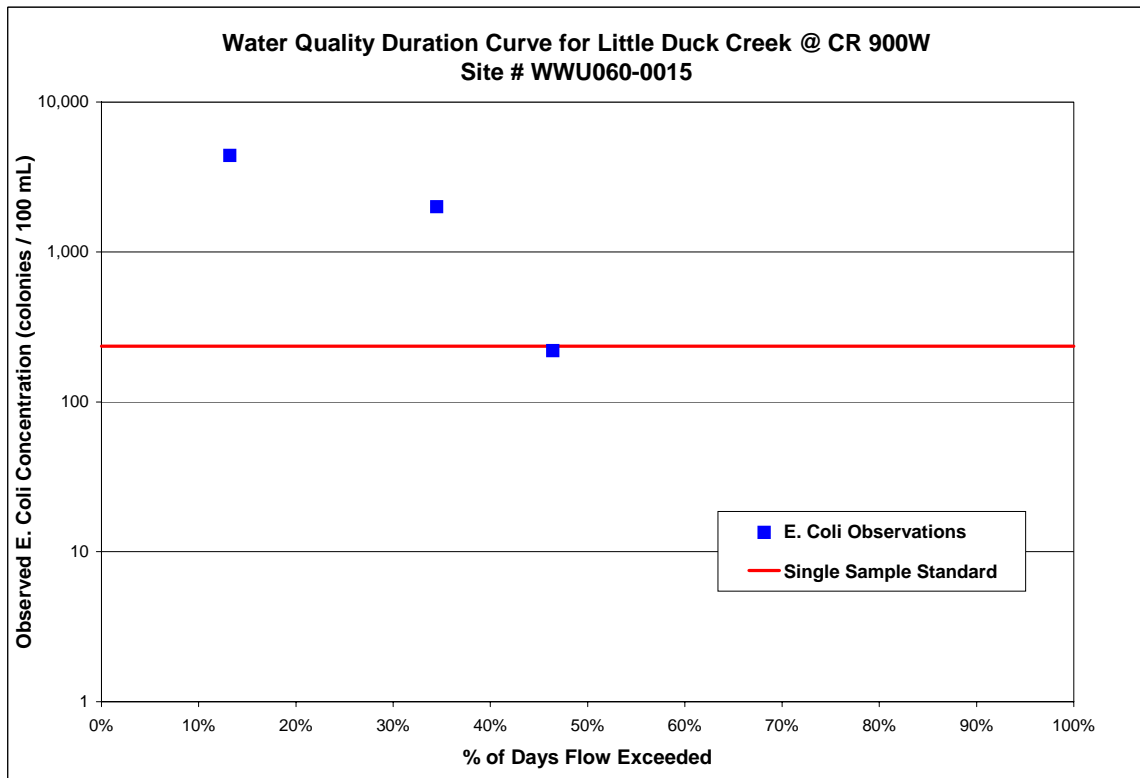
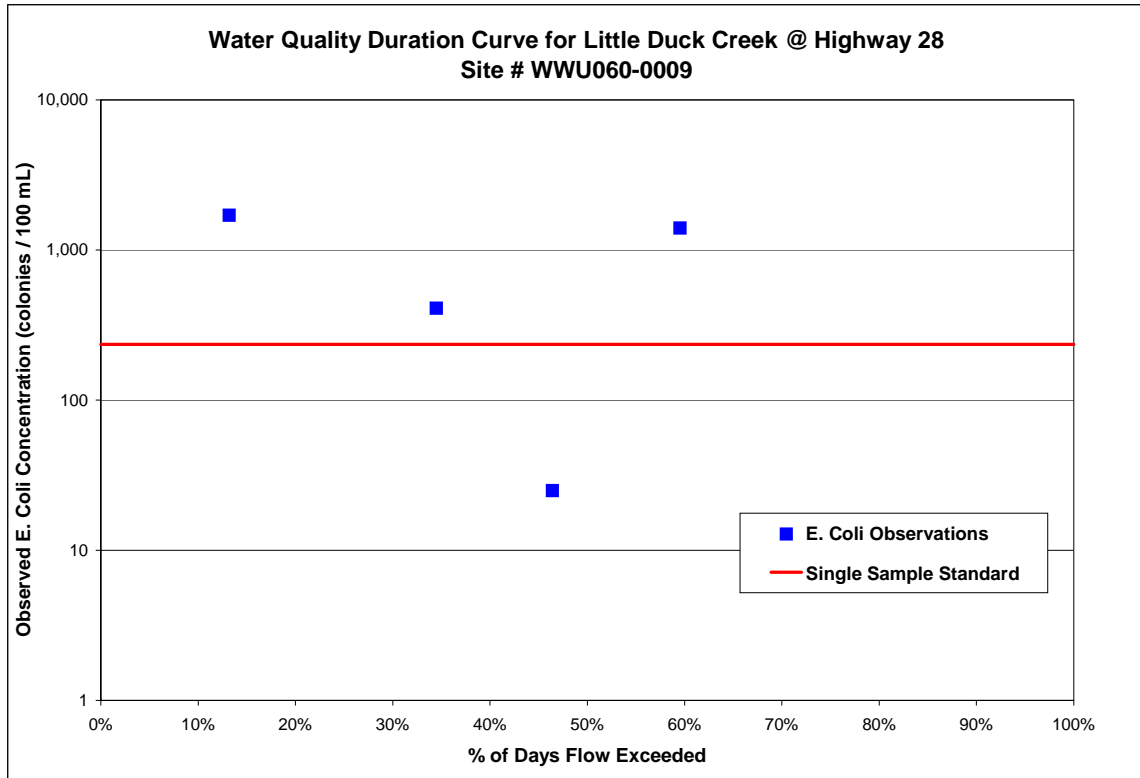
WATER QUALITY DURATION CURVES

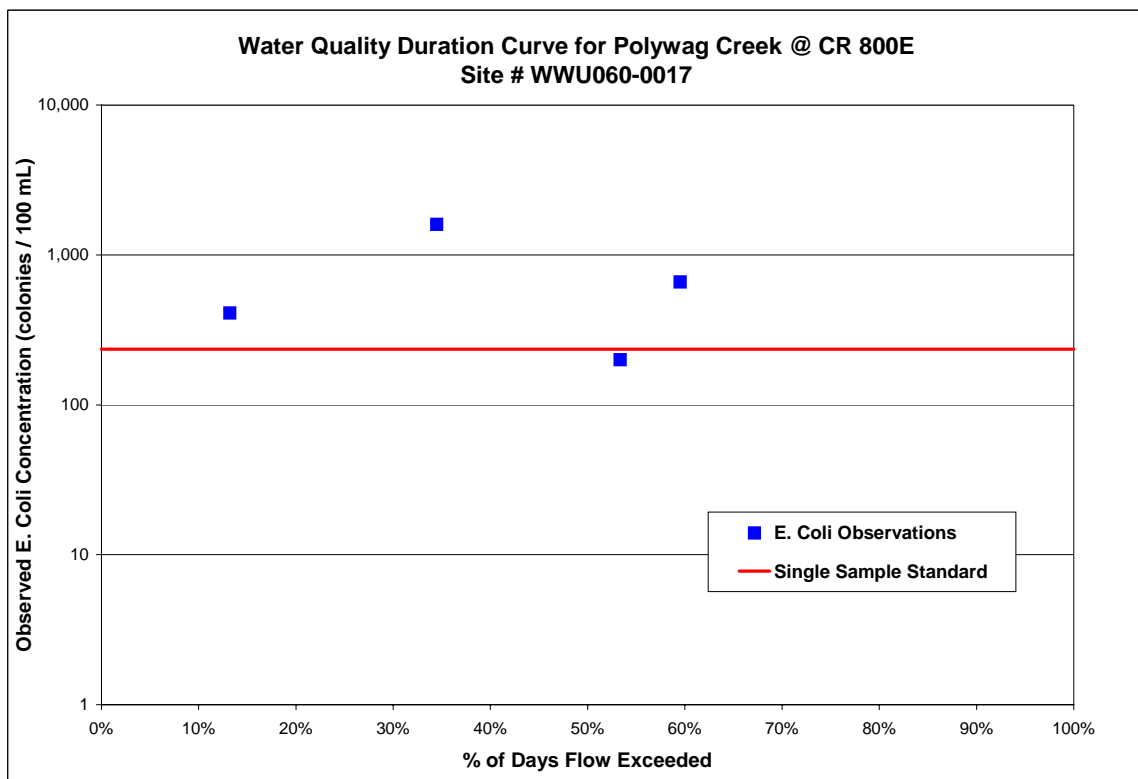
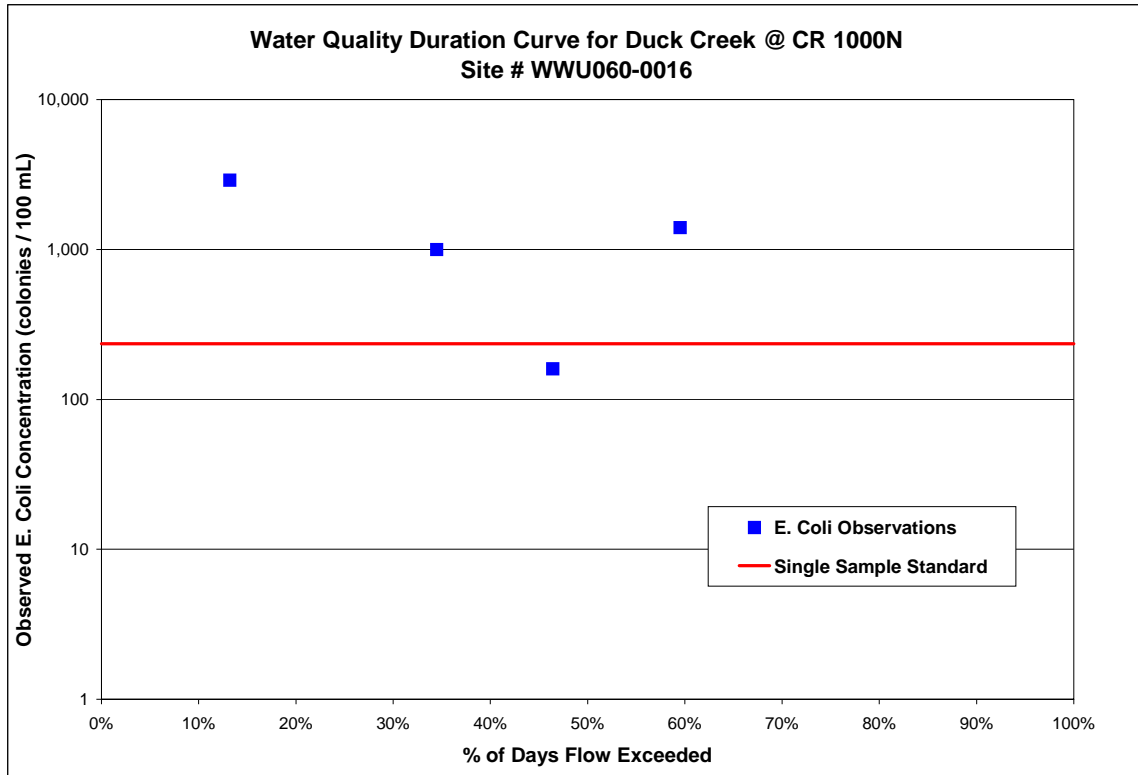
Water Quality Duration Curves for Duck Creek Watershed

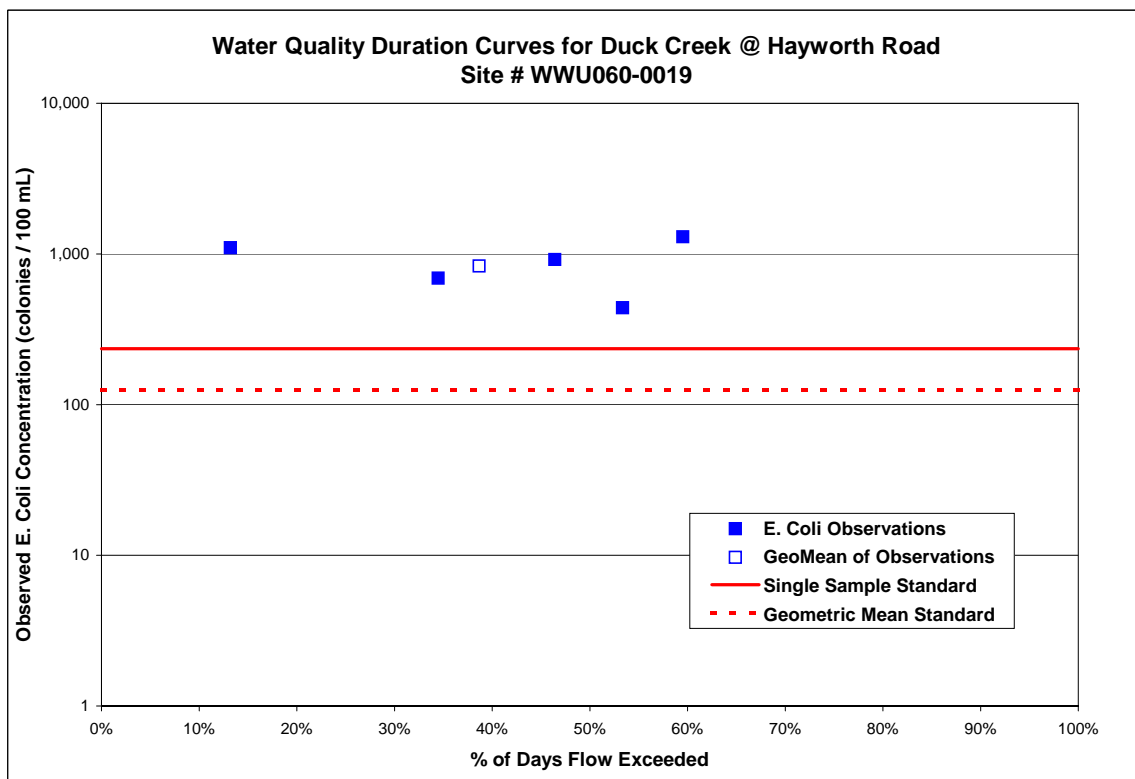
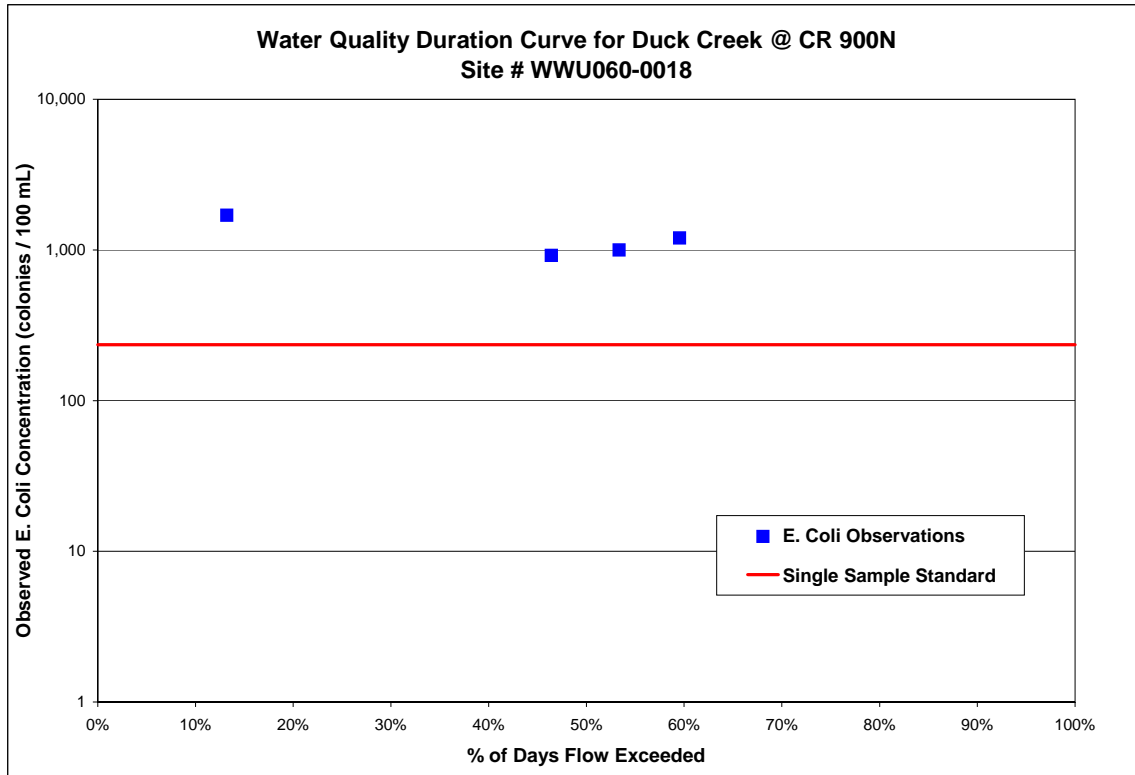


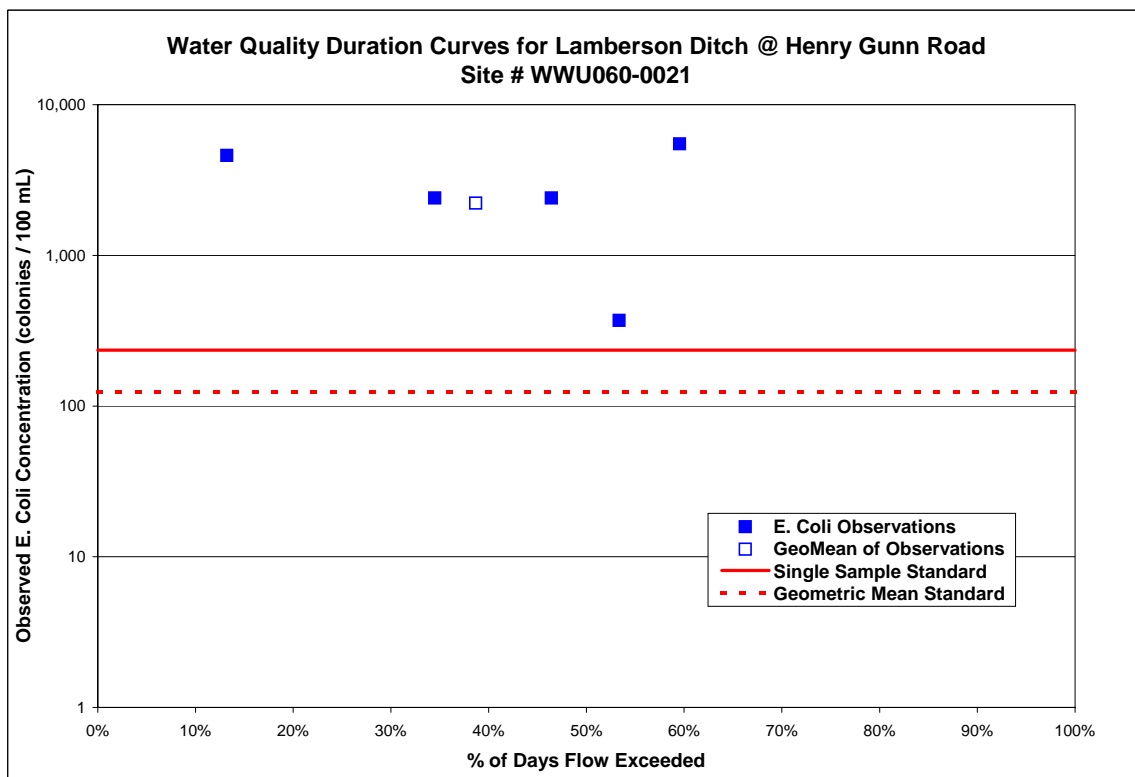
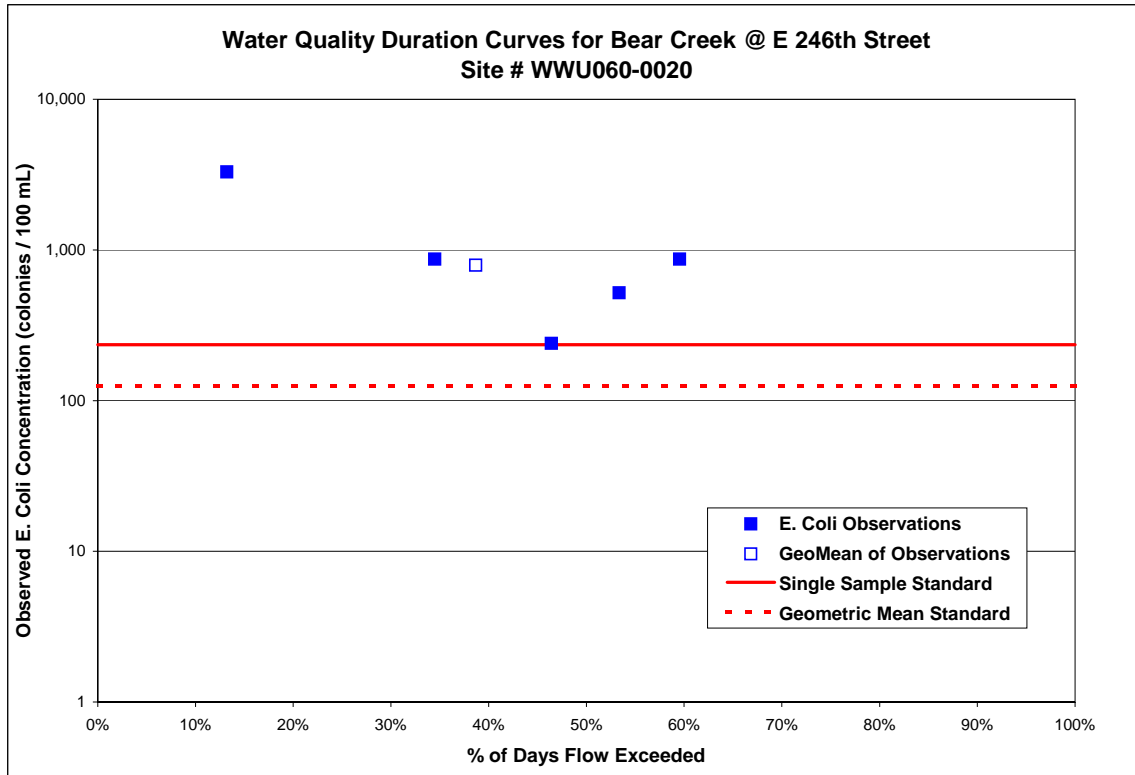


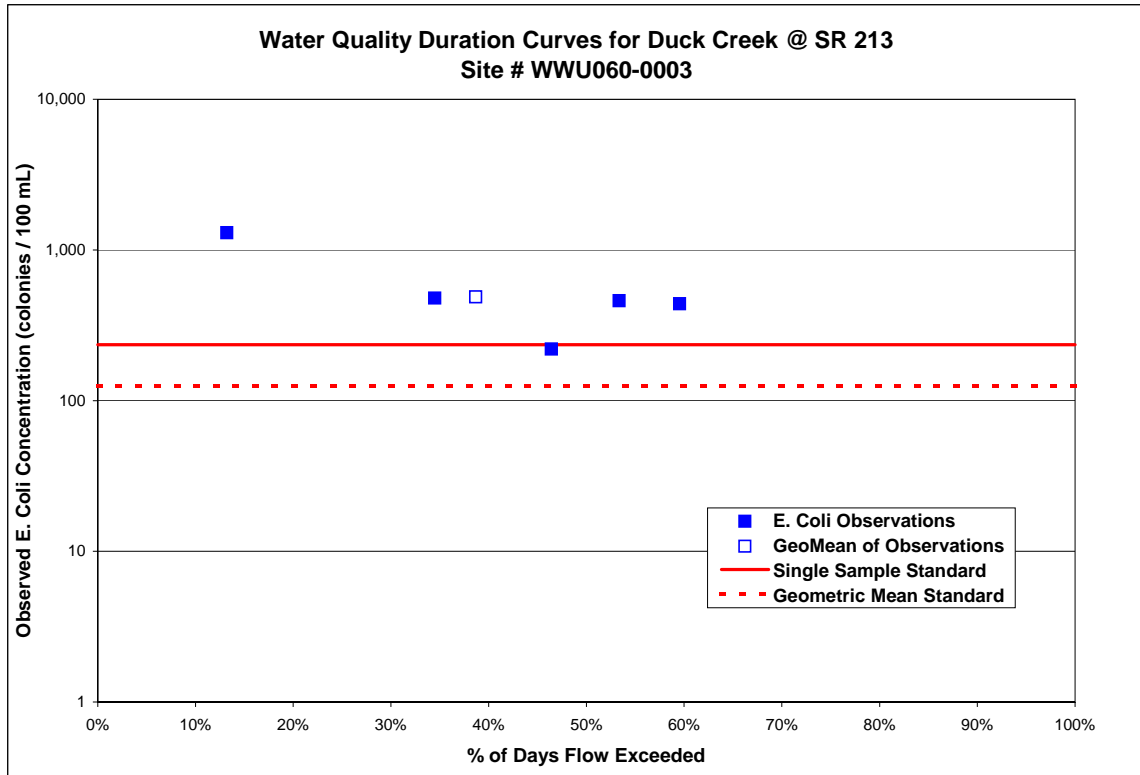




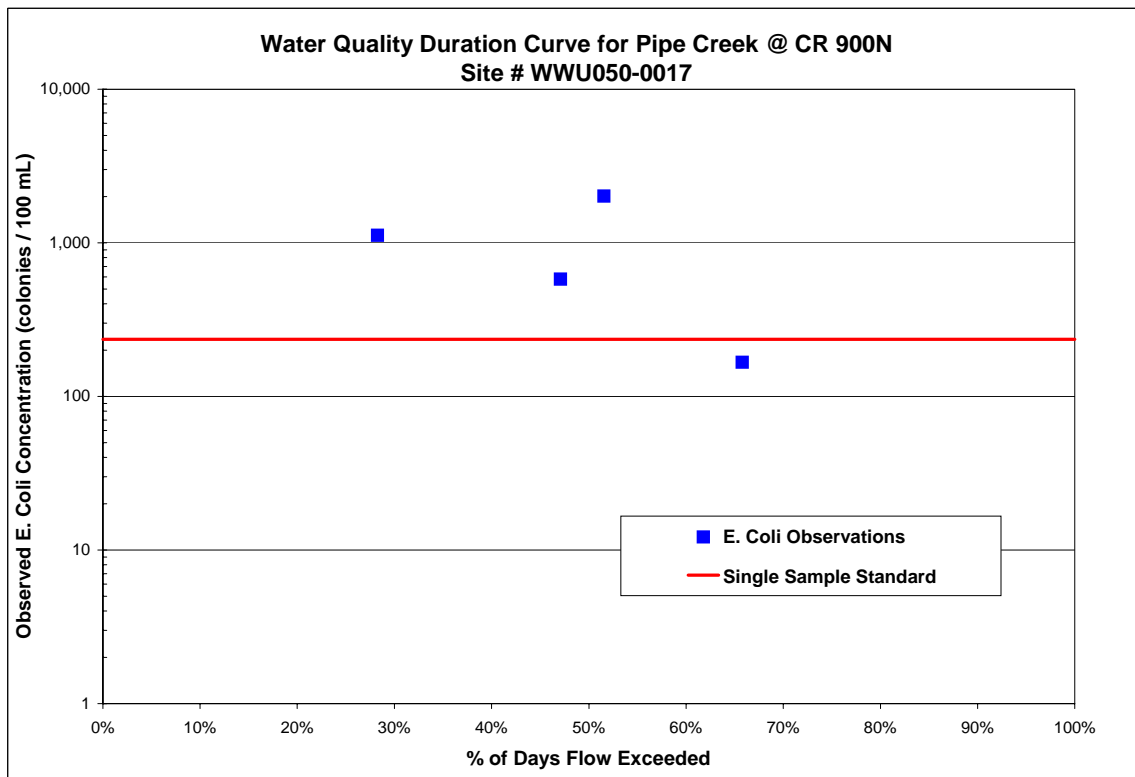
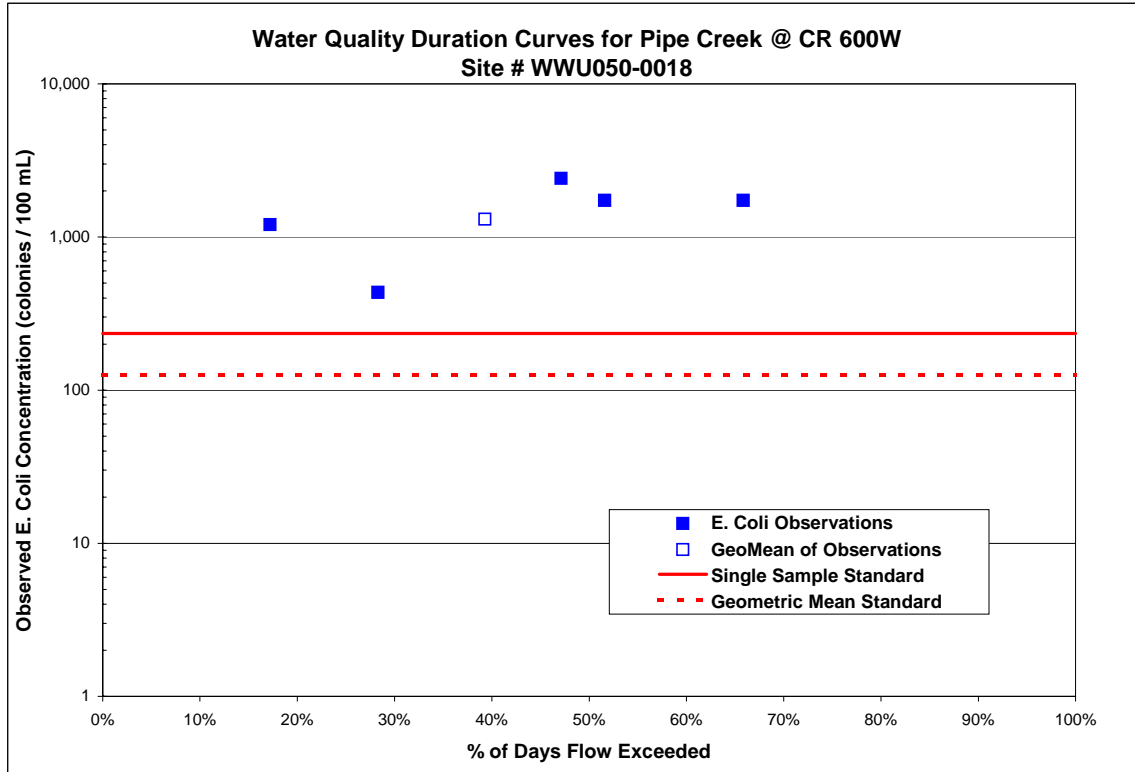


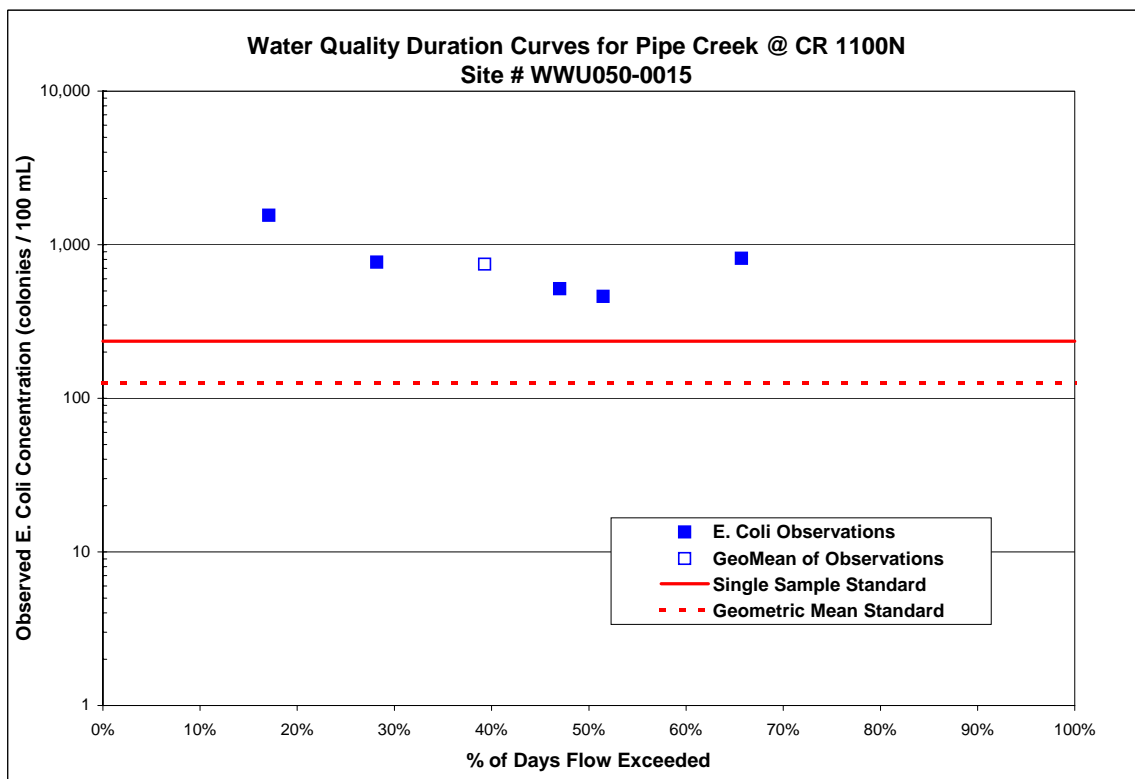
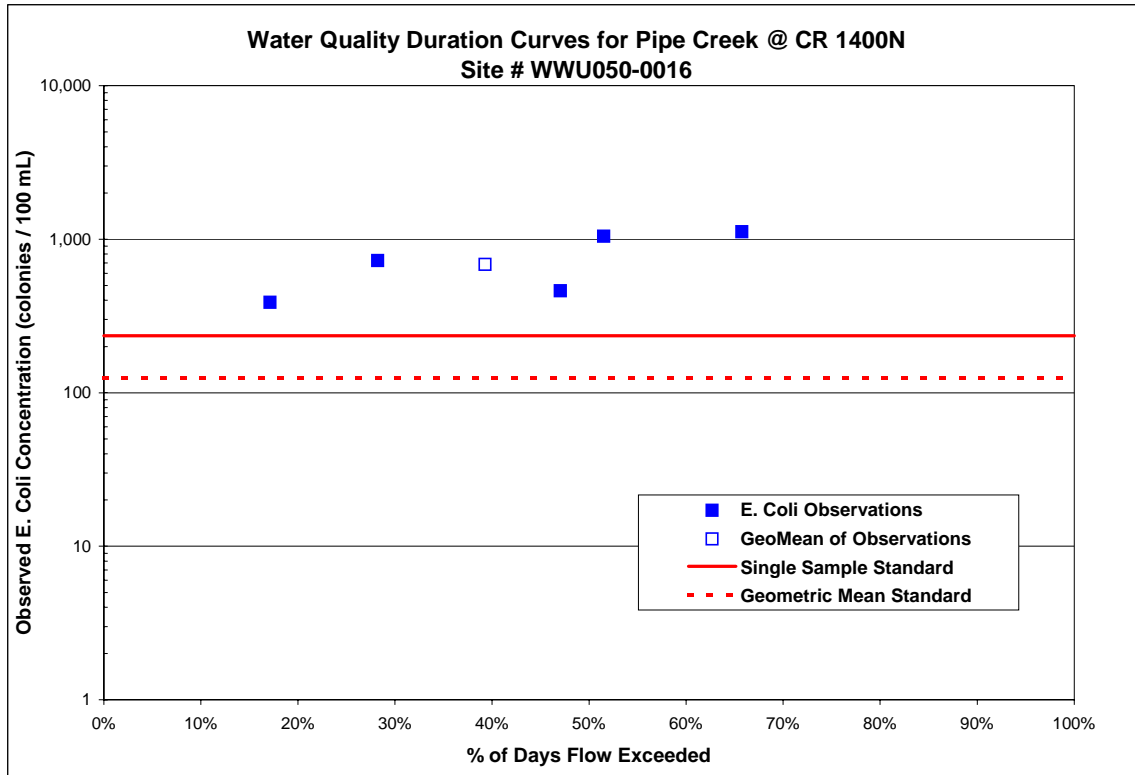


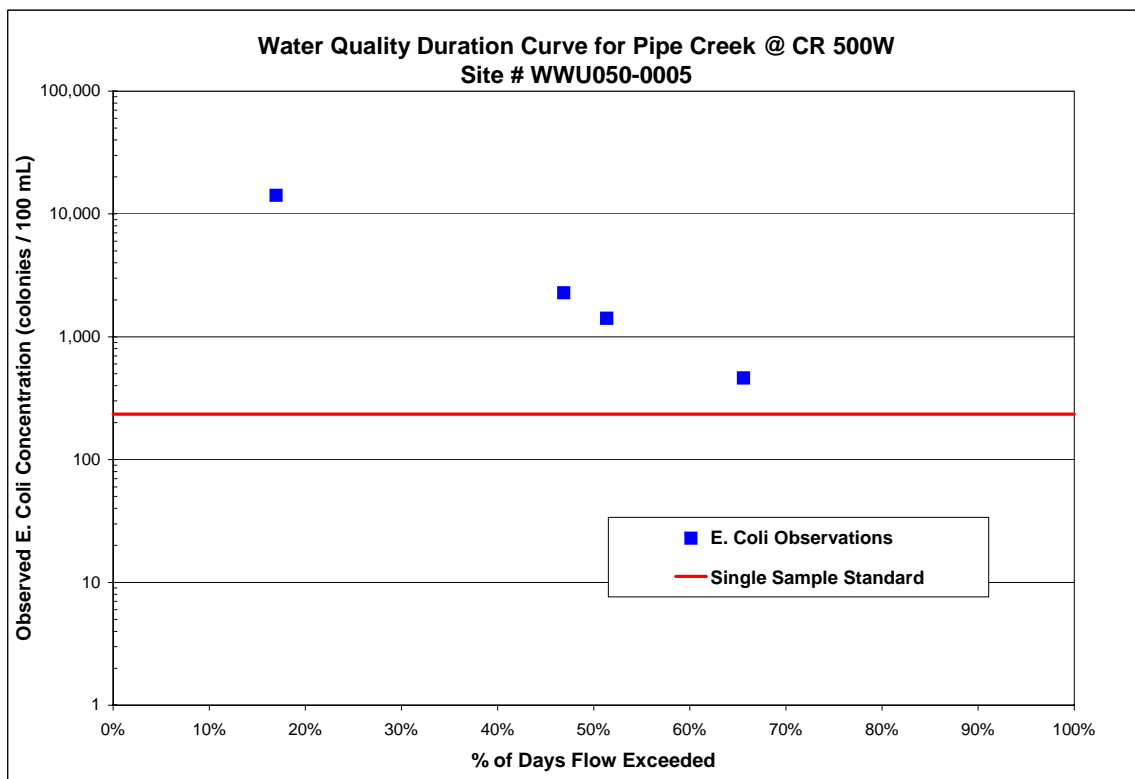
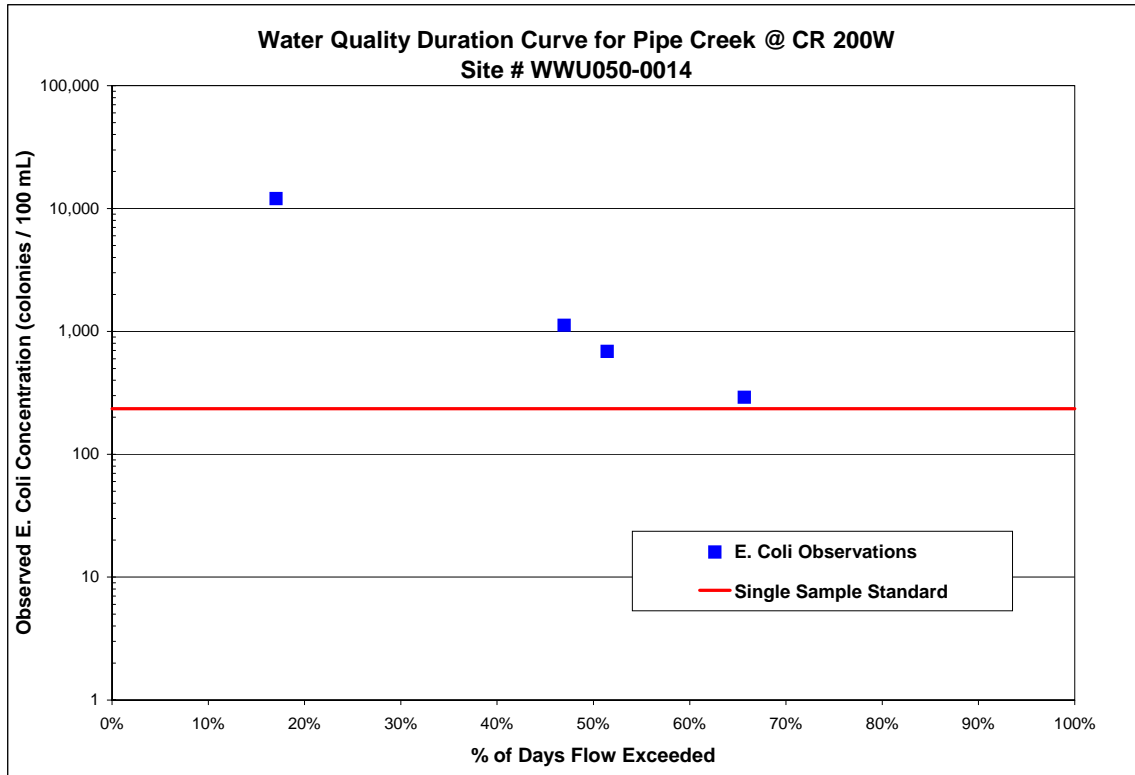


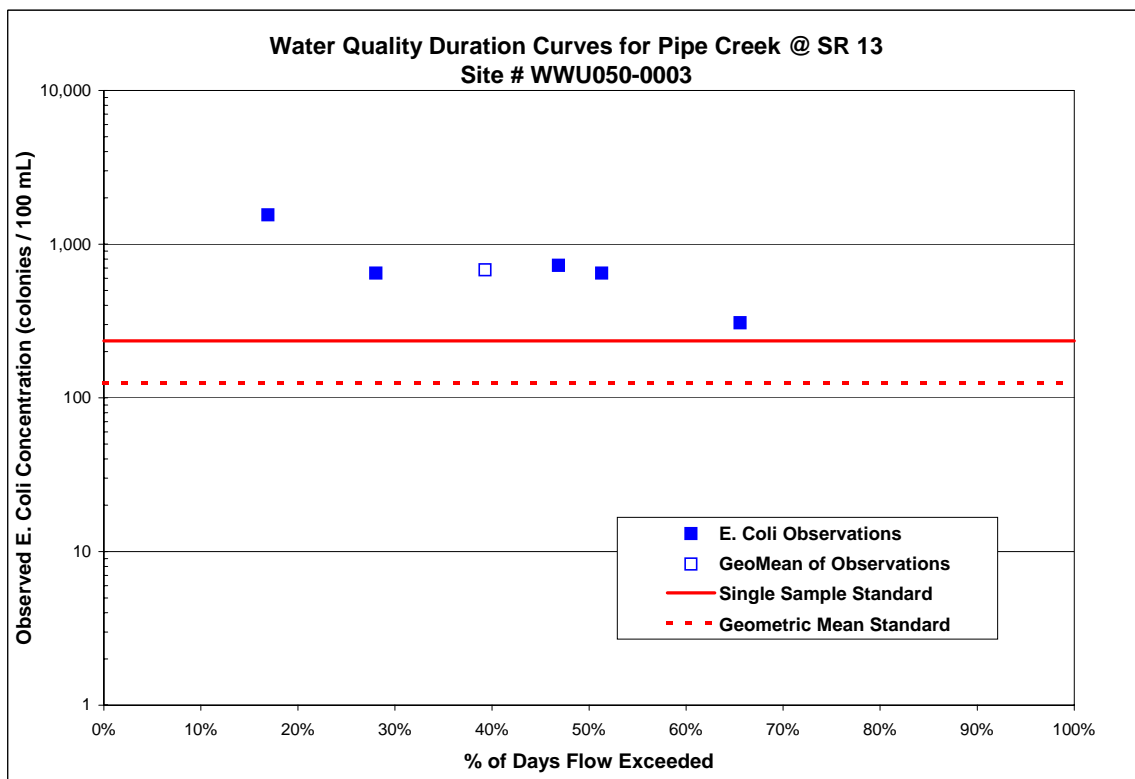
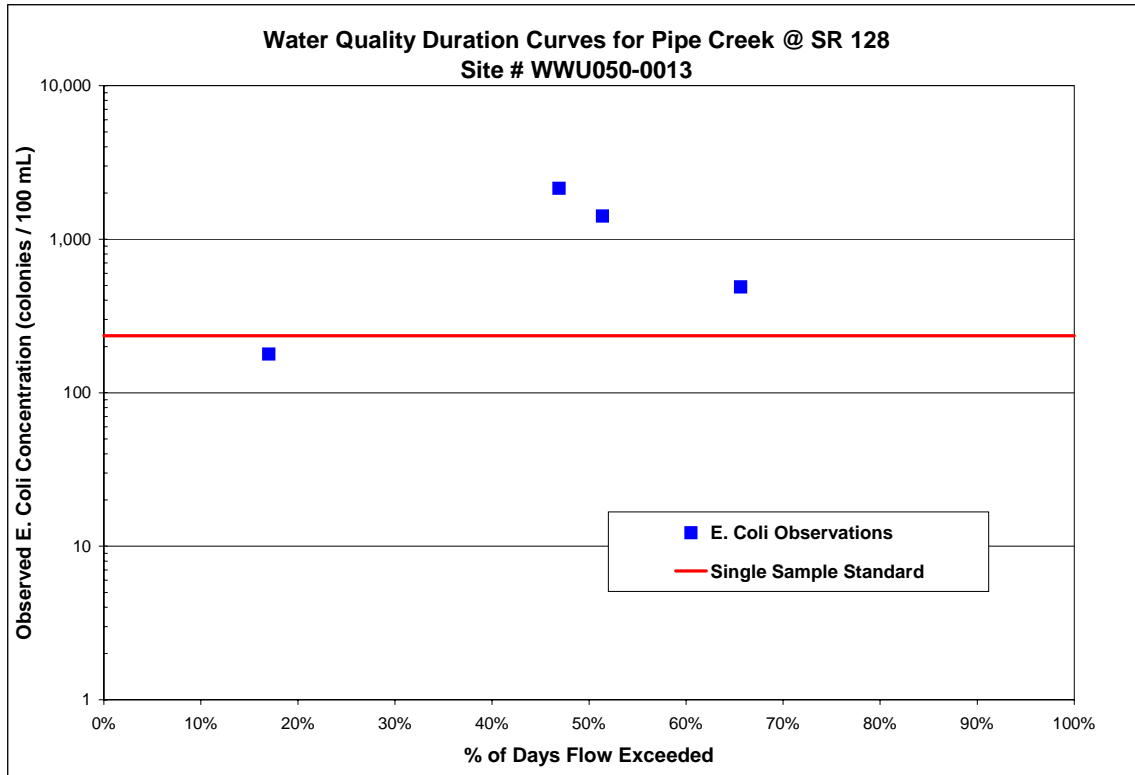


Water Quality Duration Curves for Pipe Creek Watershed

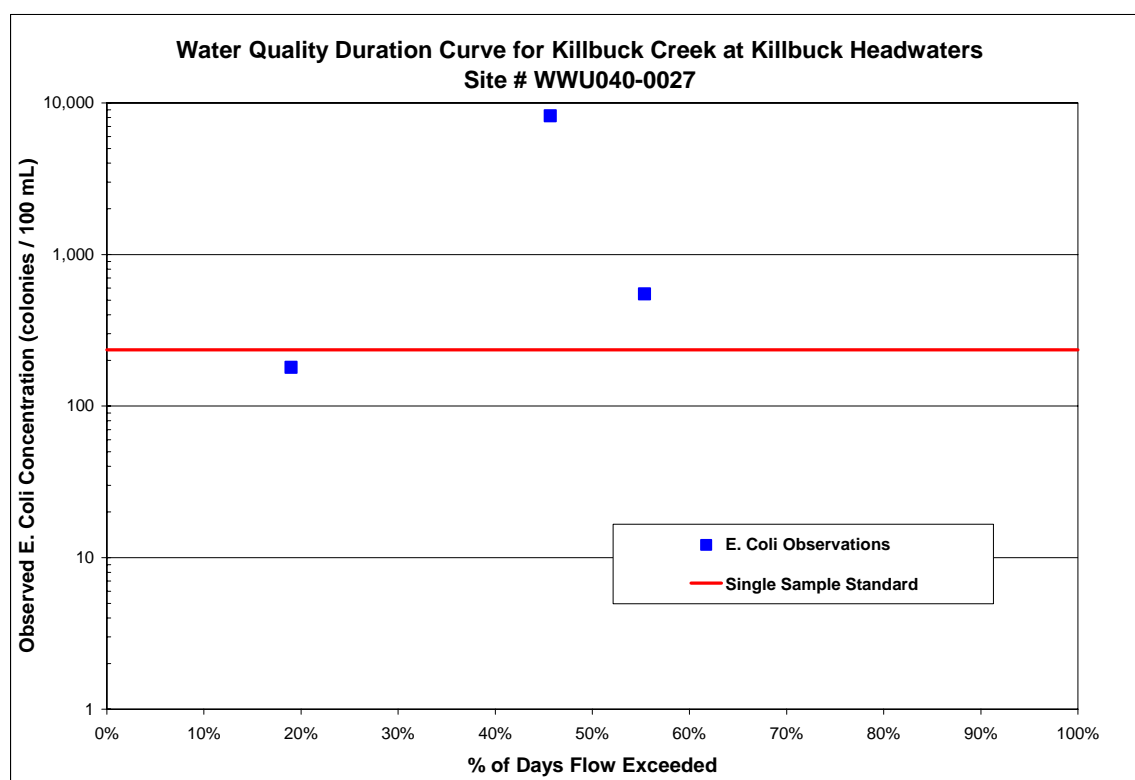
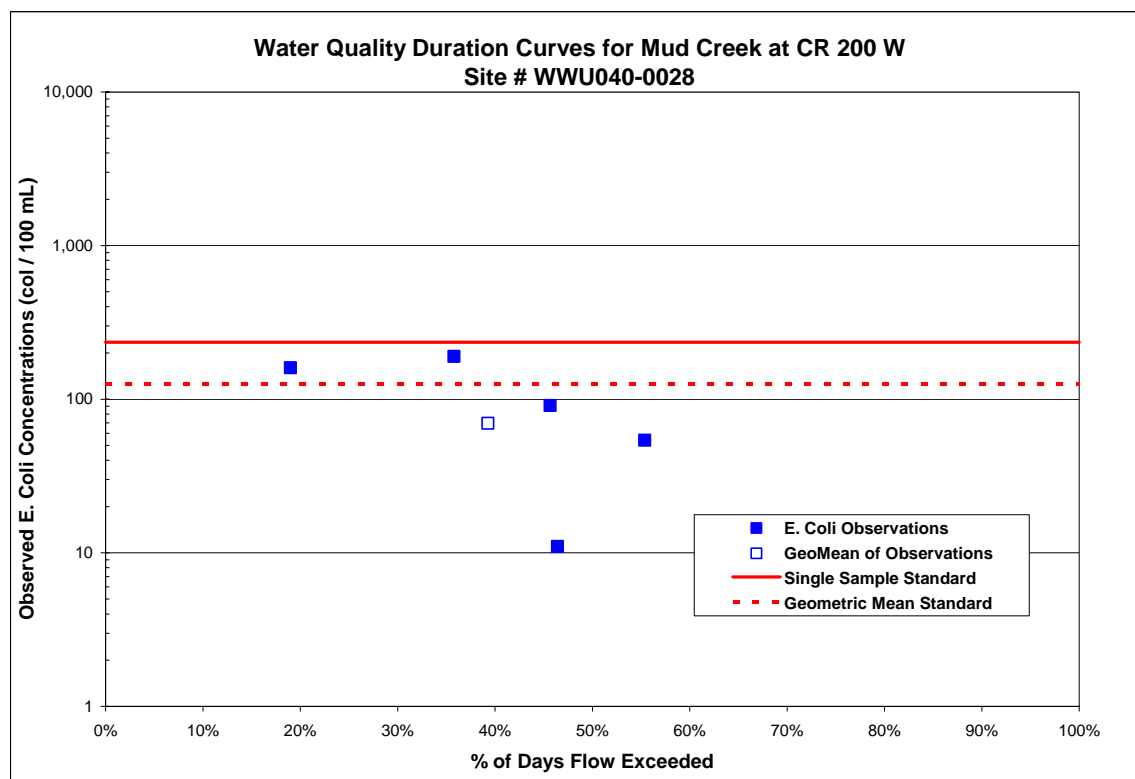


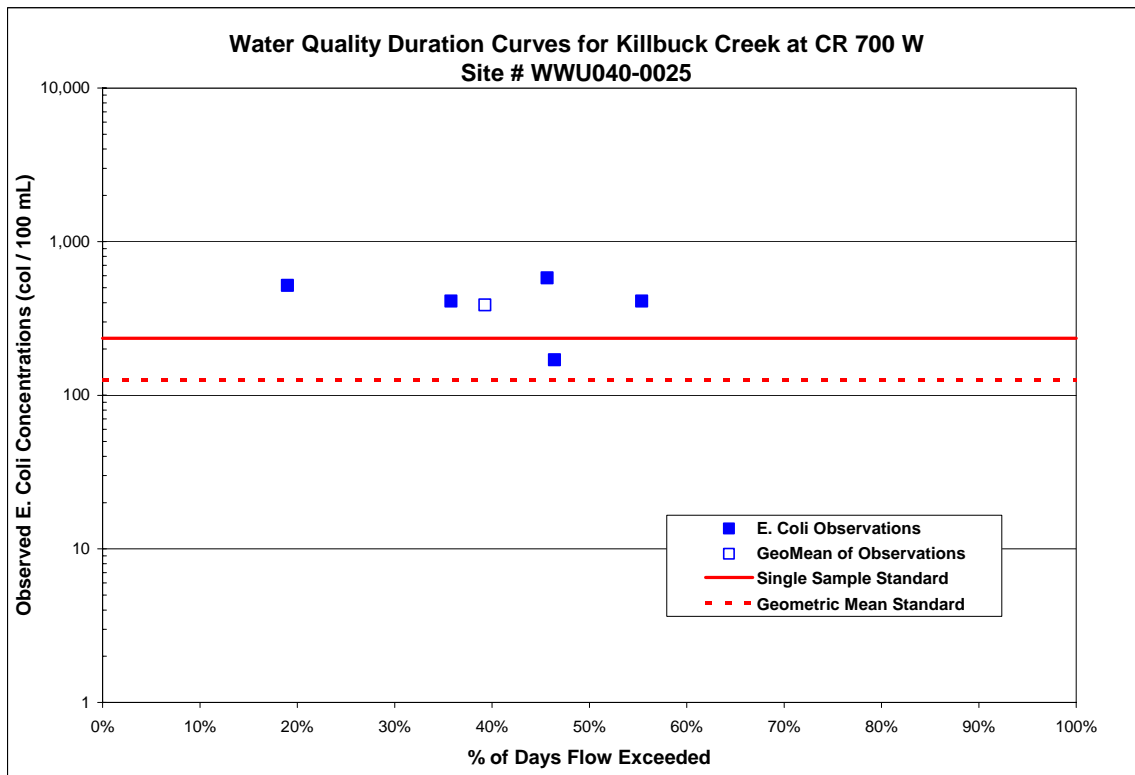
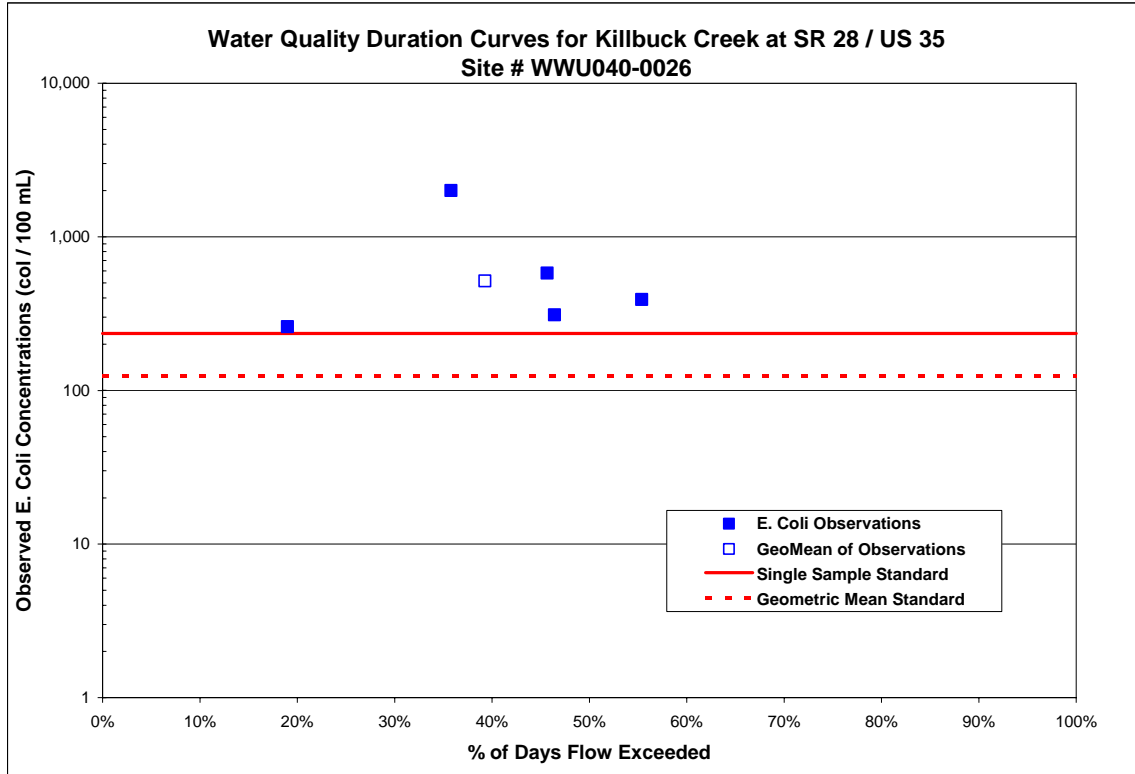


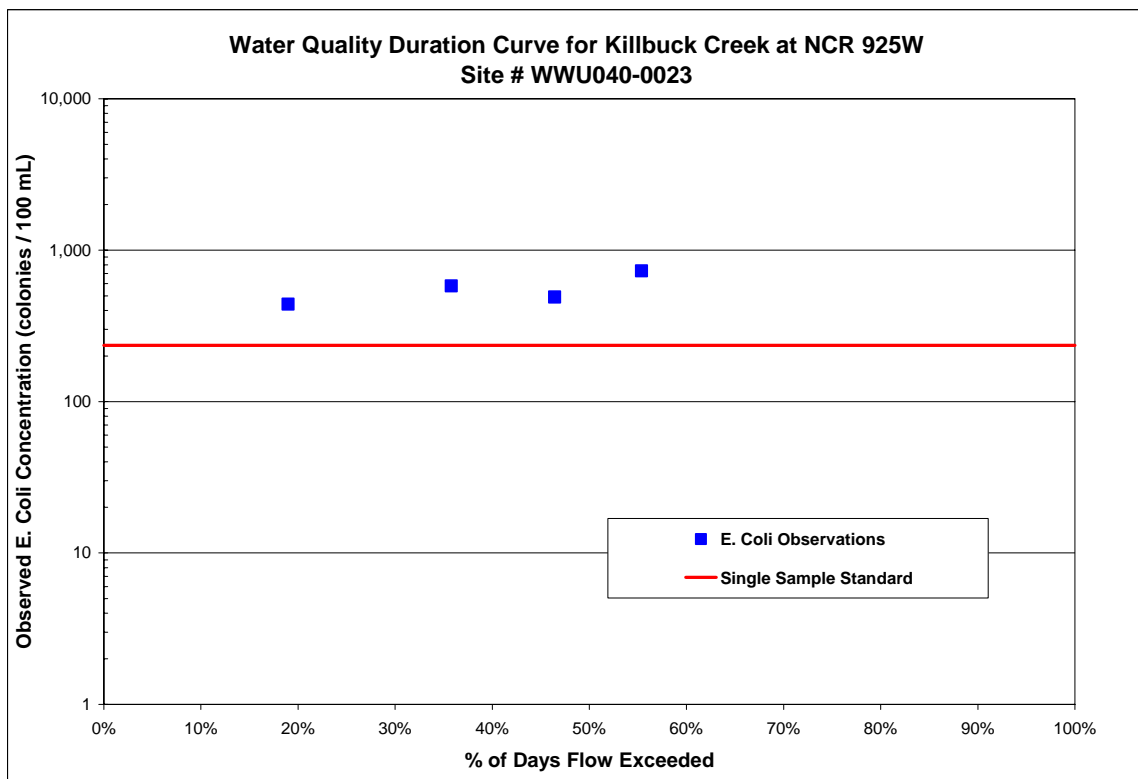
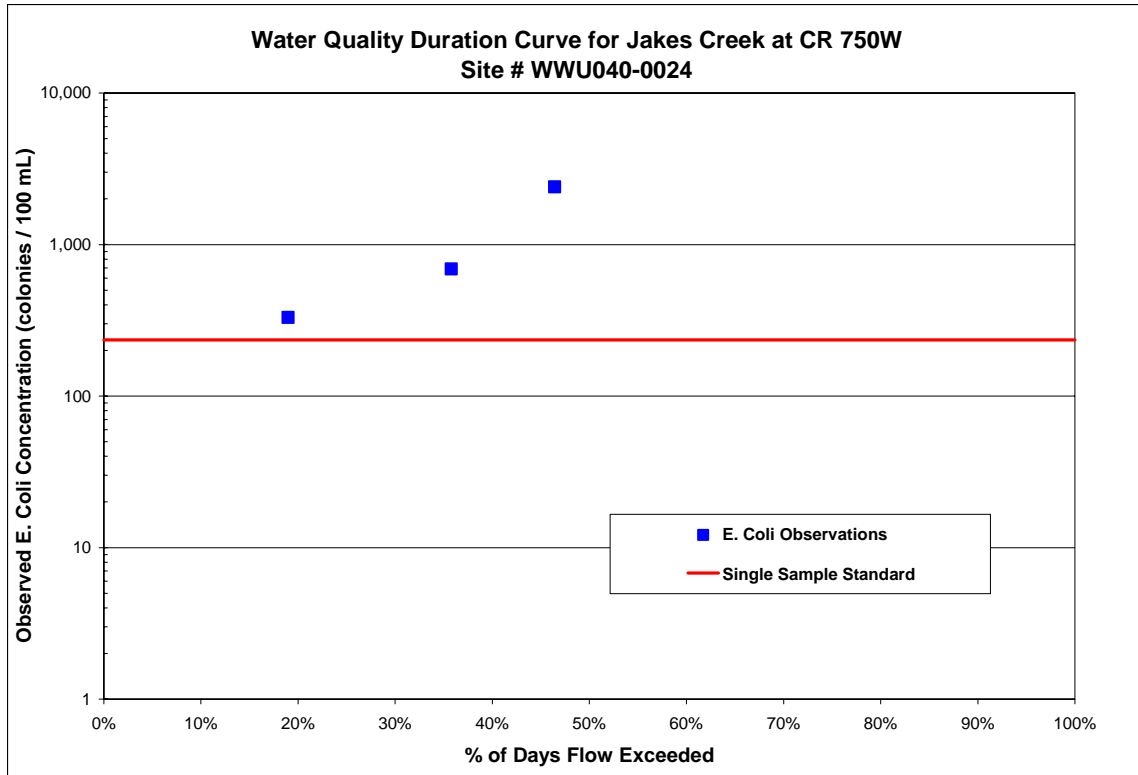


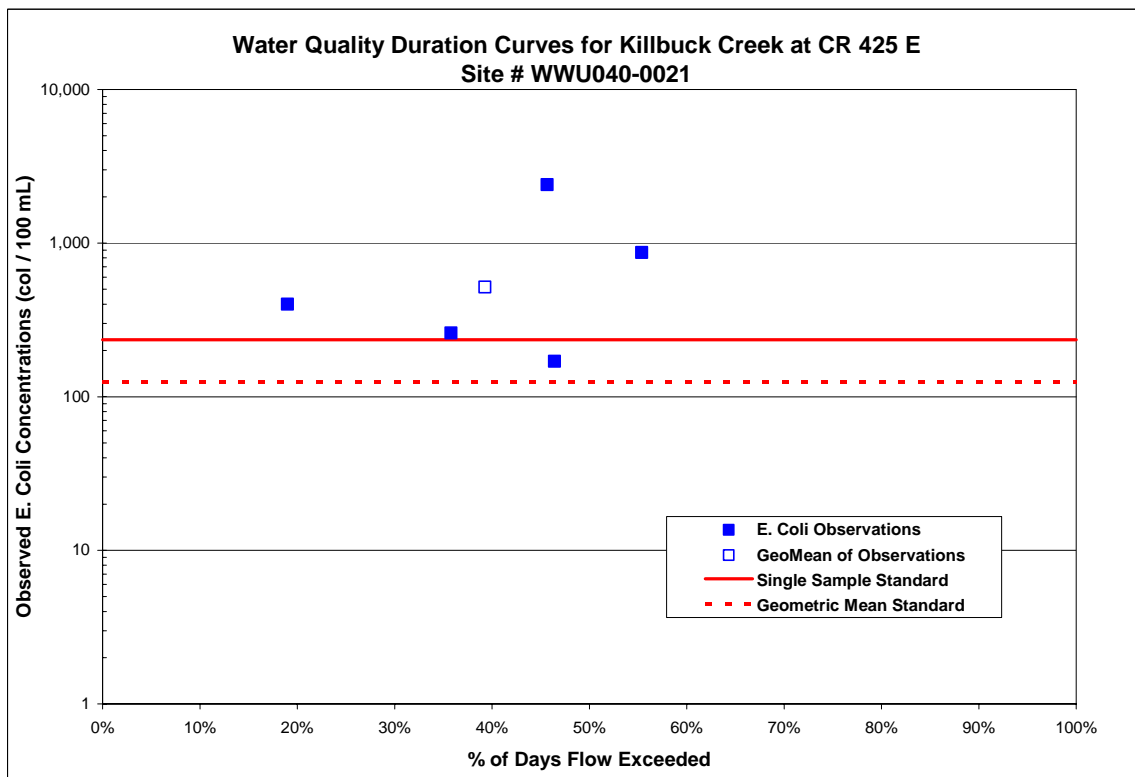
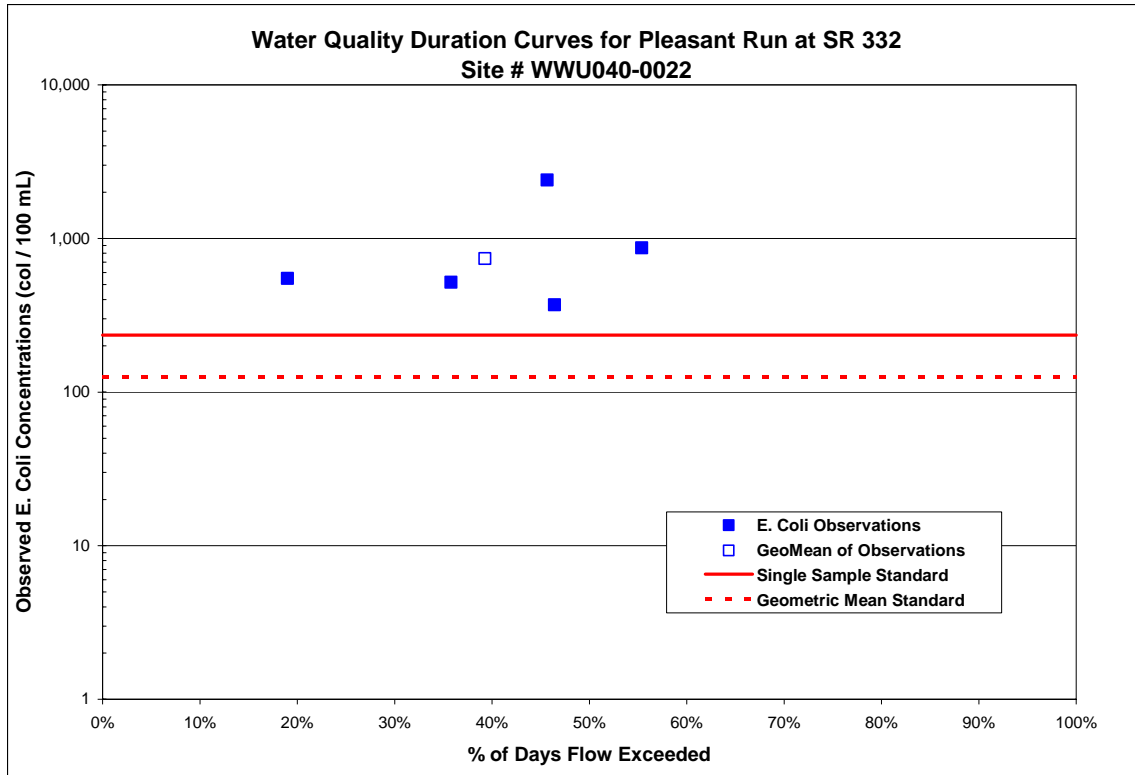


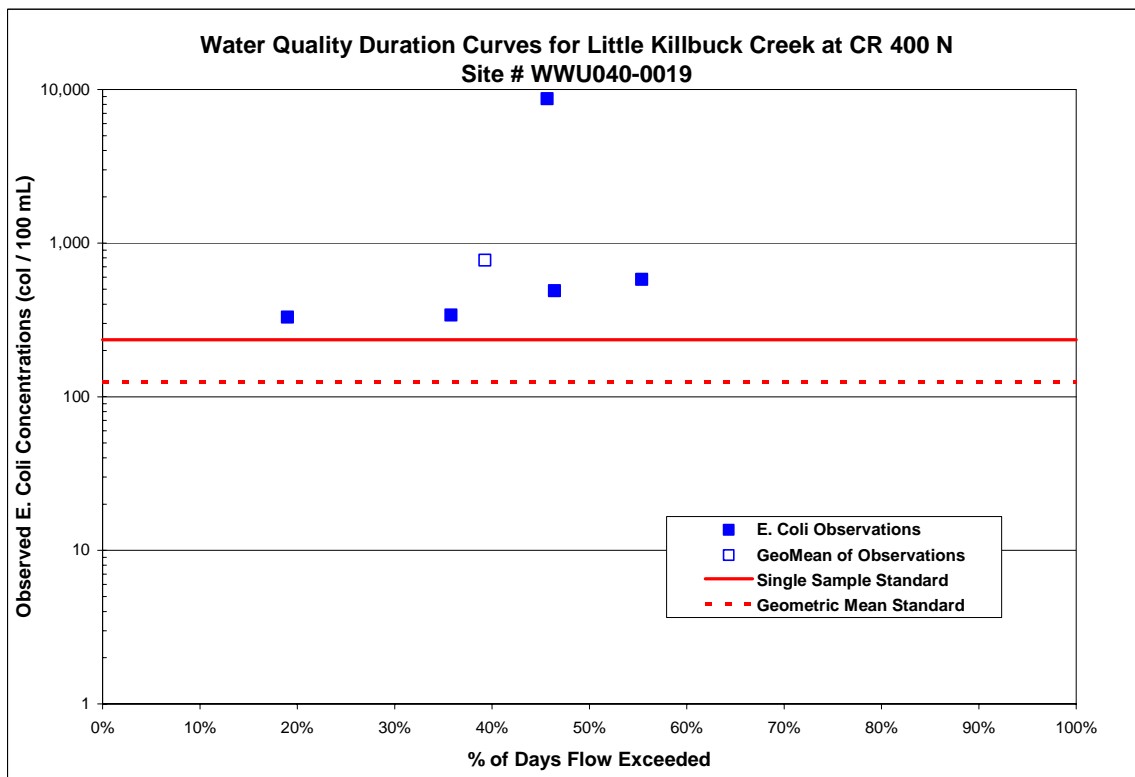
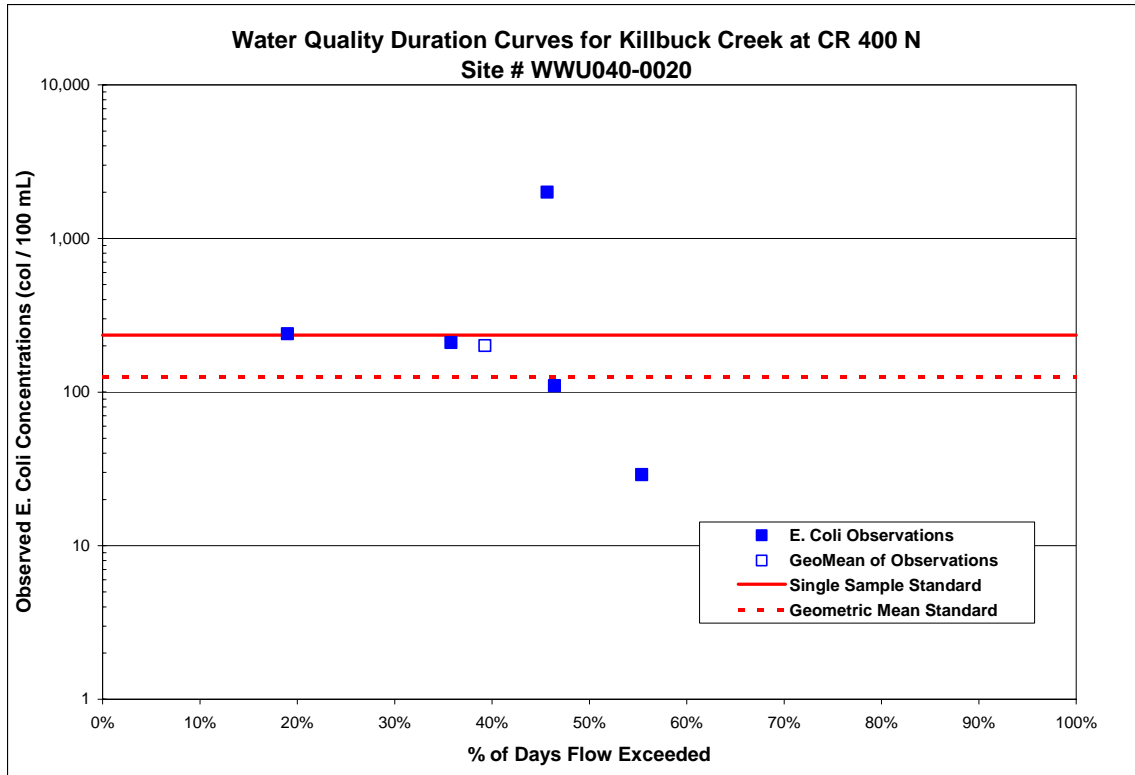
Water Quality Duration Curves for Killbuck Creek Watershed

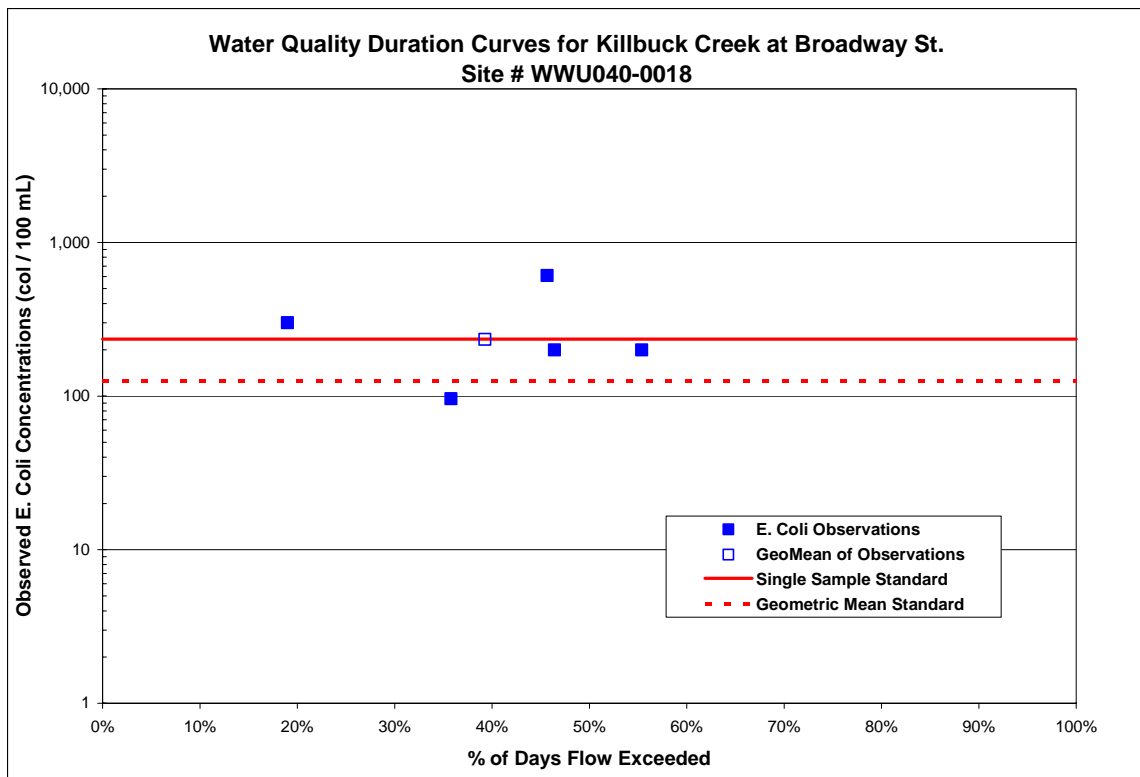
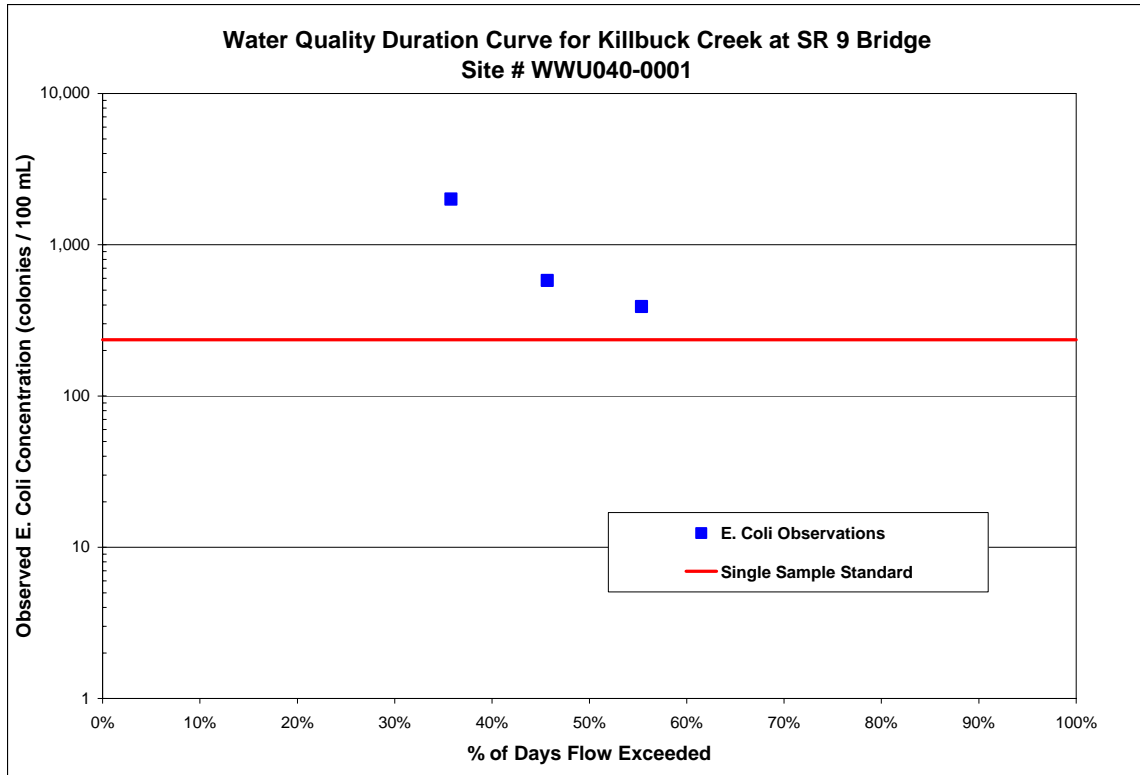




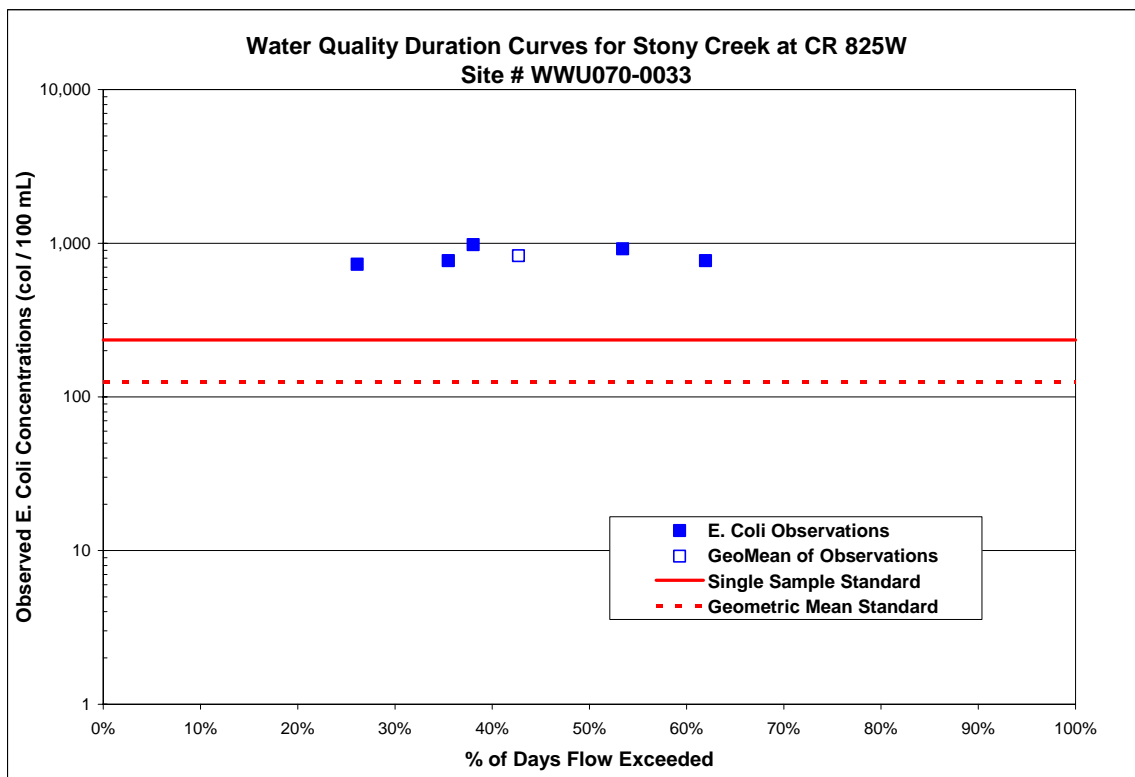
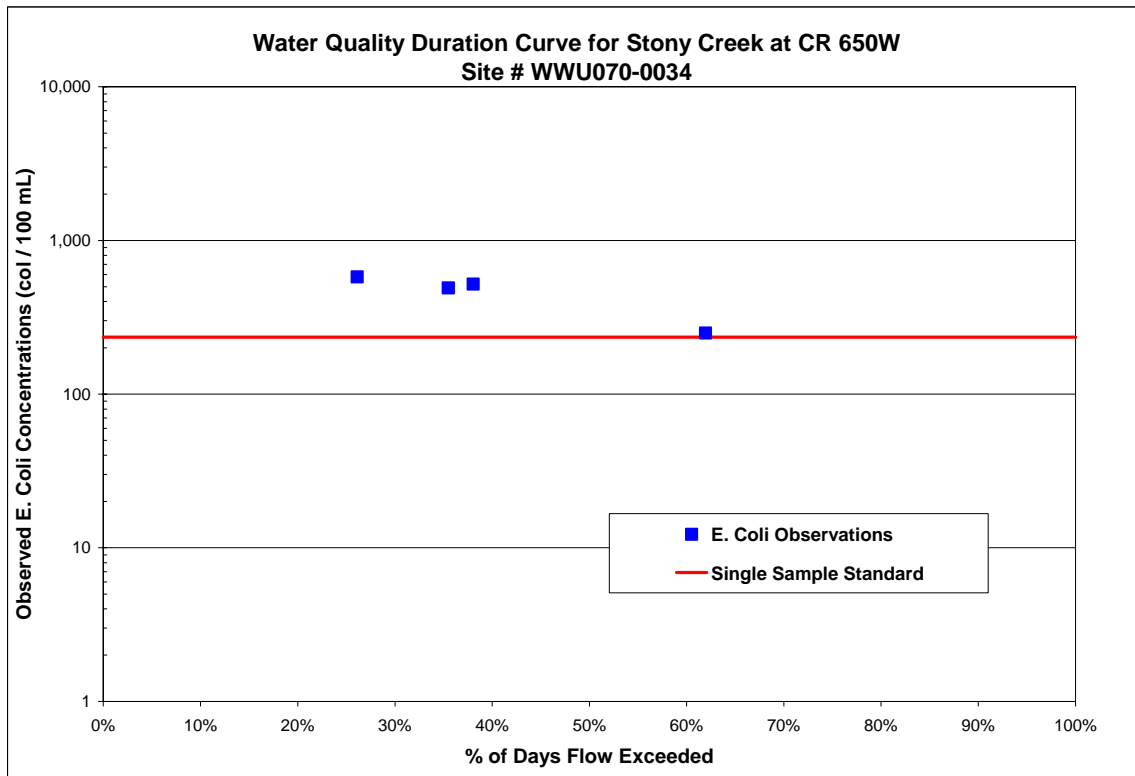


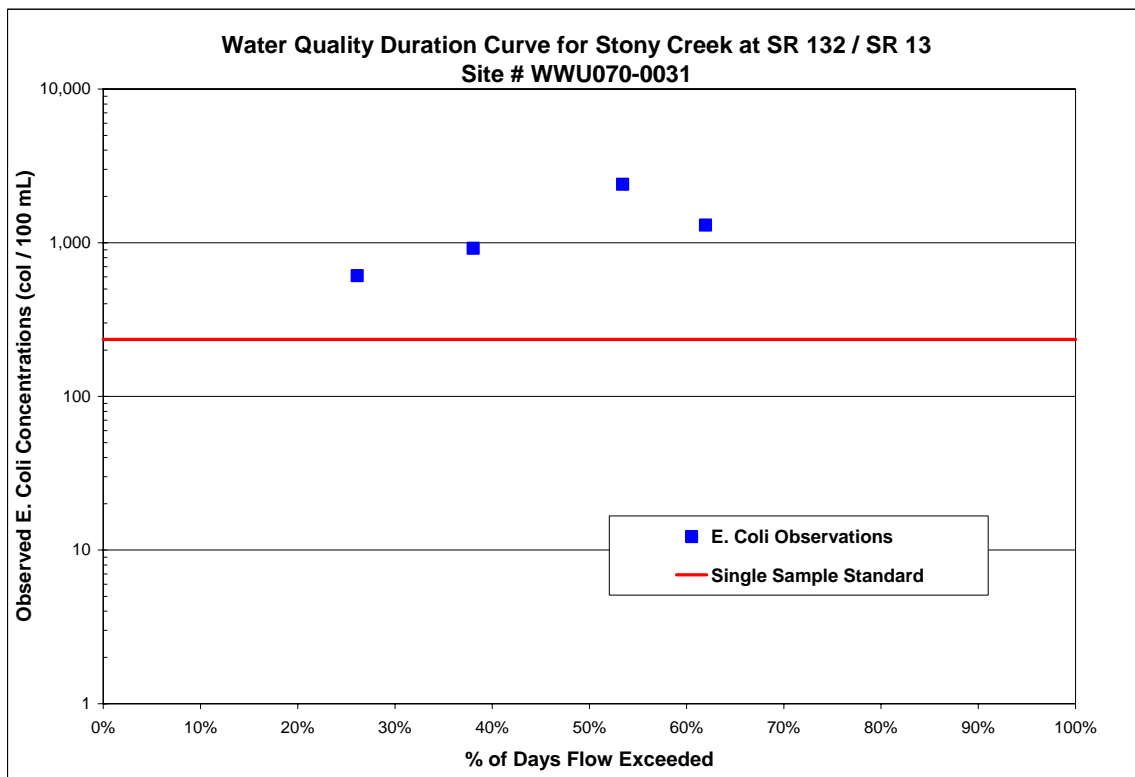
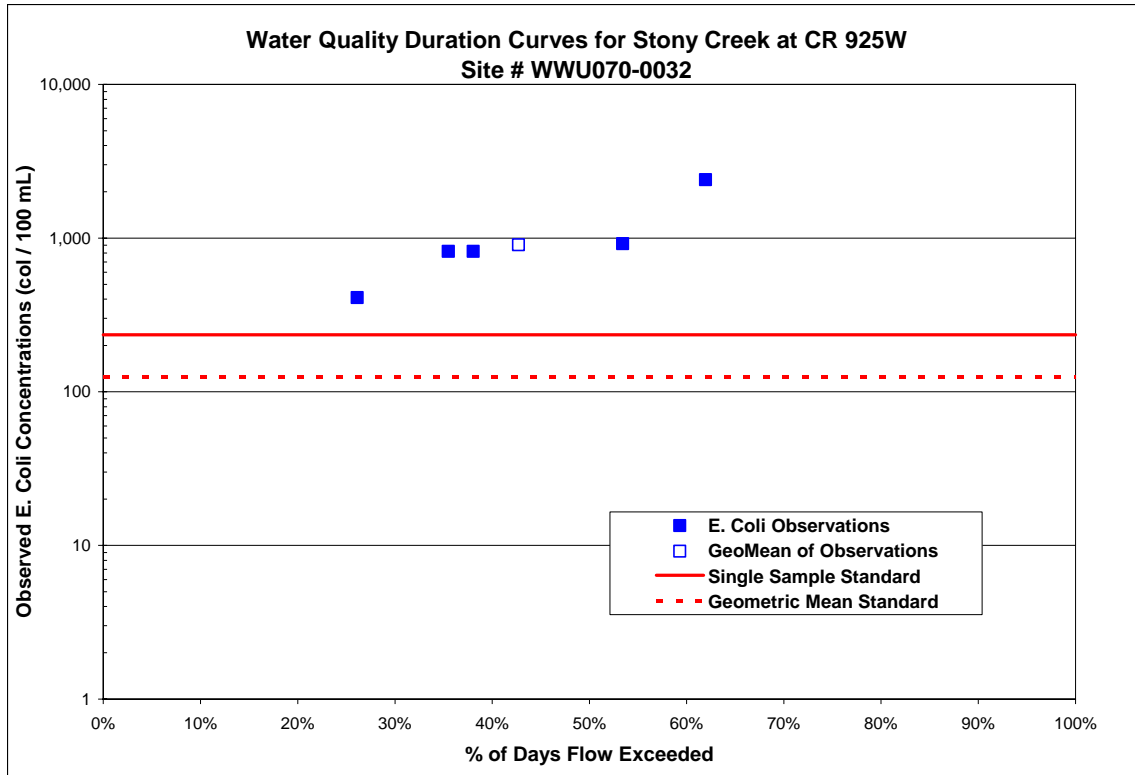


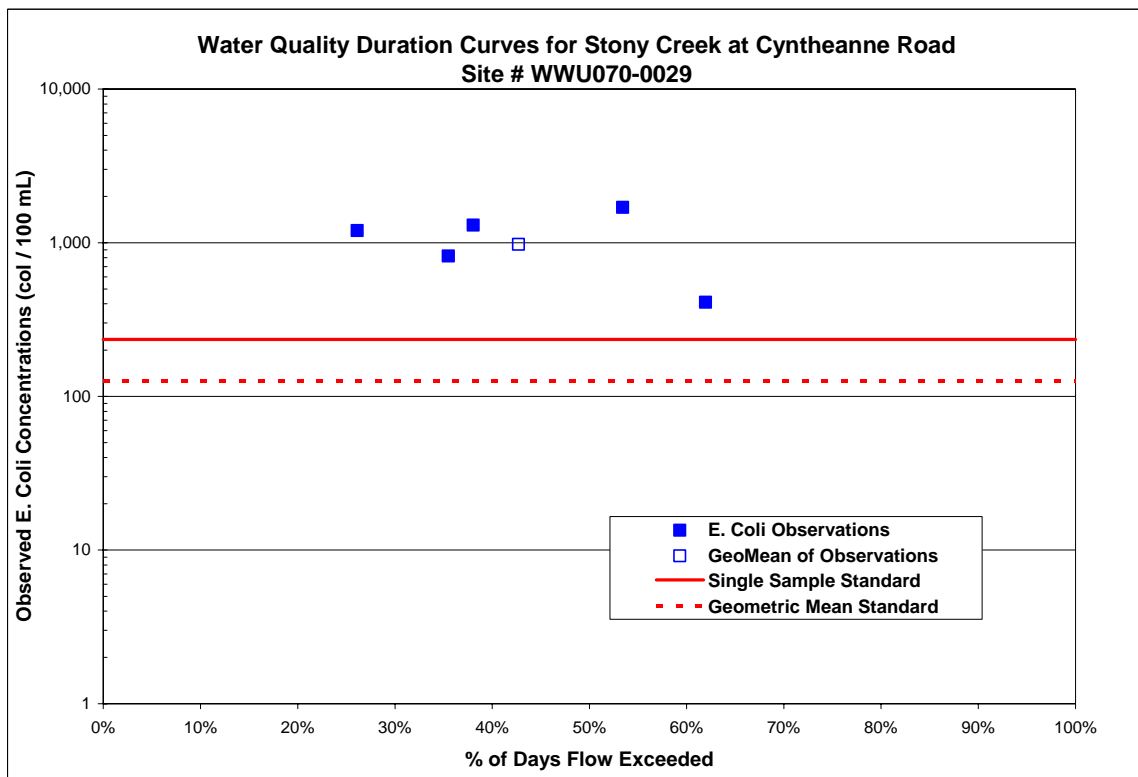
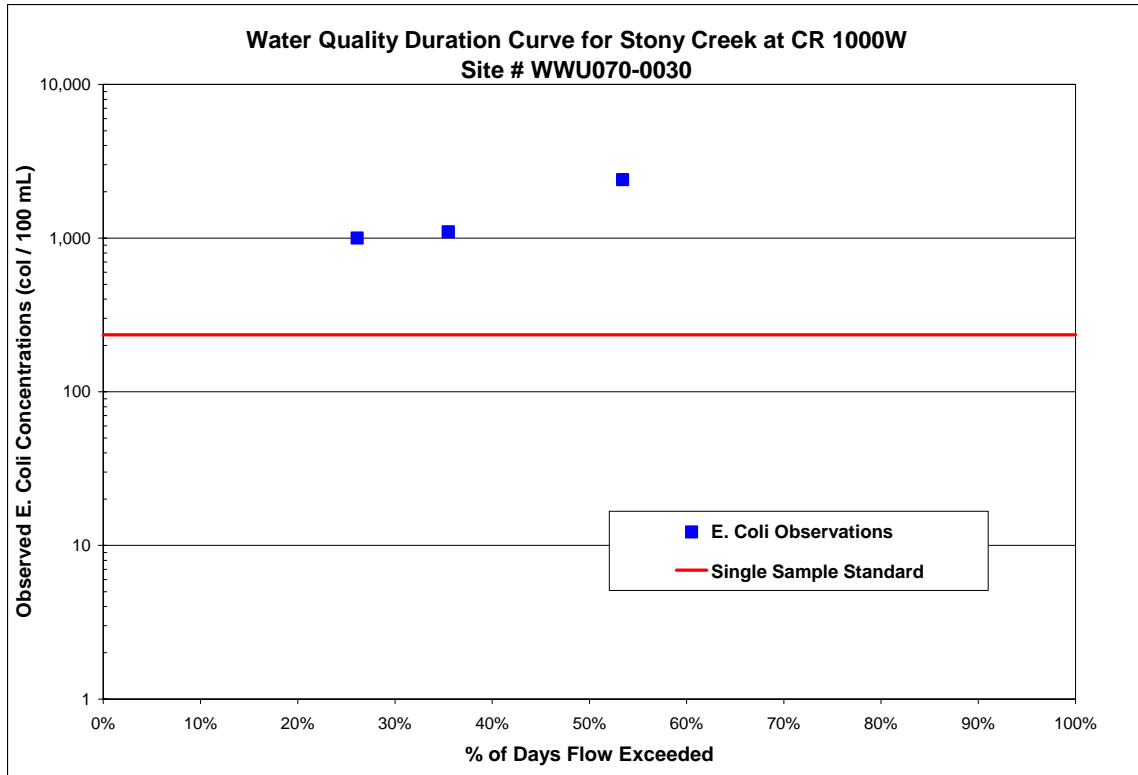


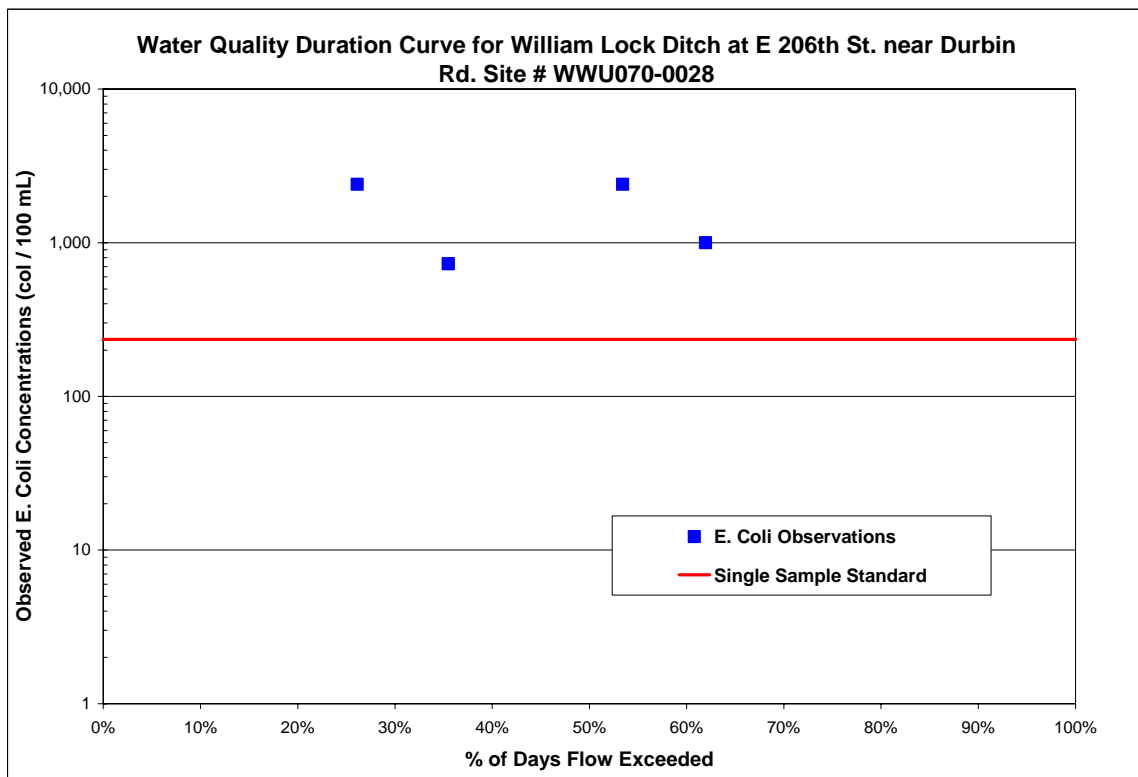
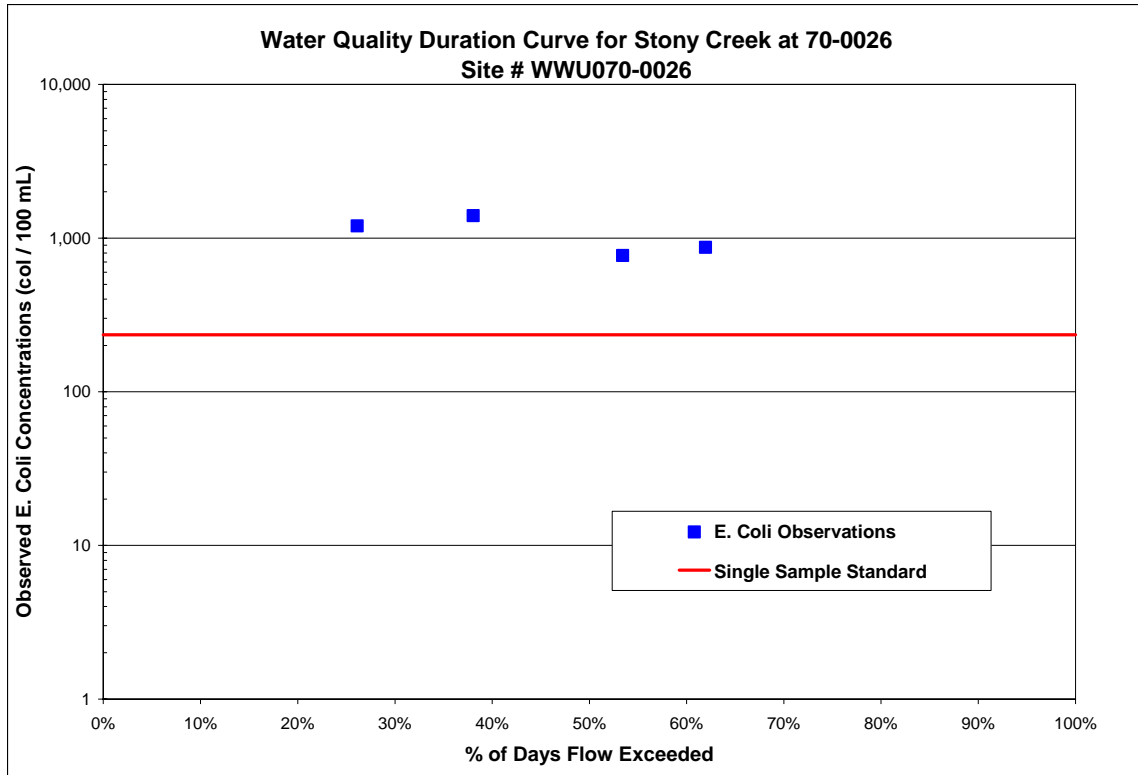


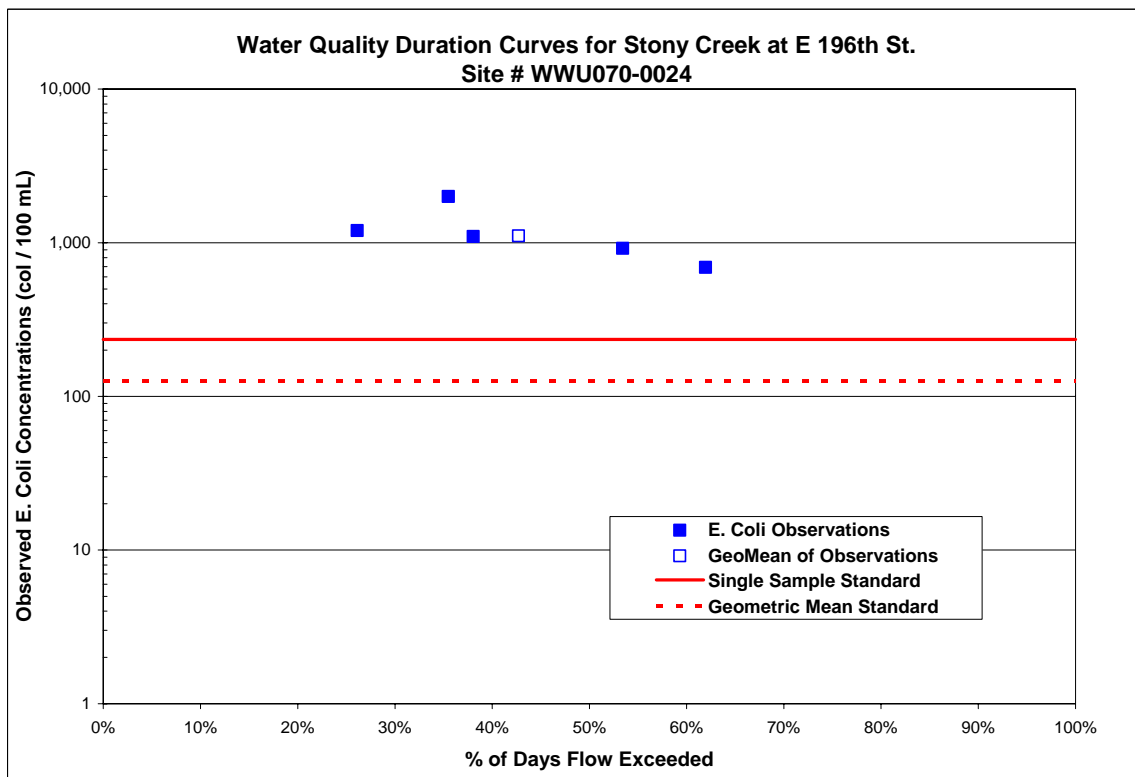
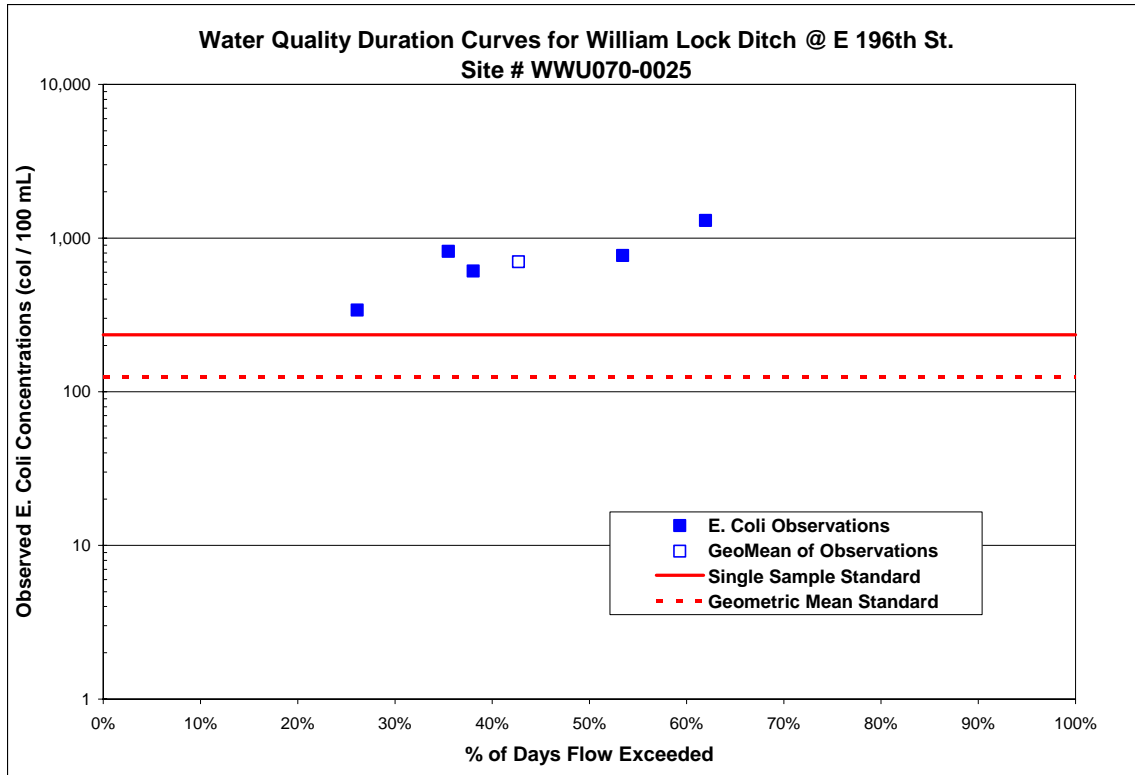
Water Quality Duration Curves for Stony Creek Watershed

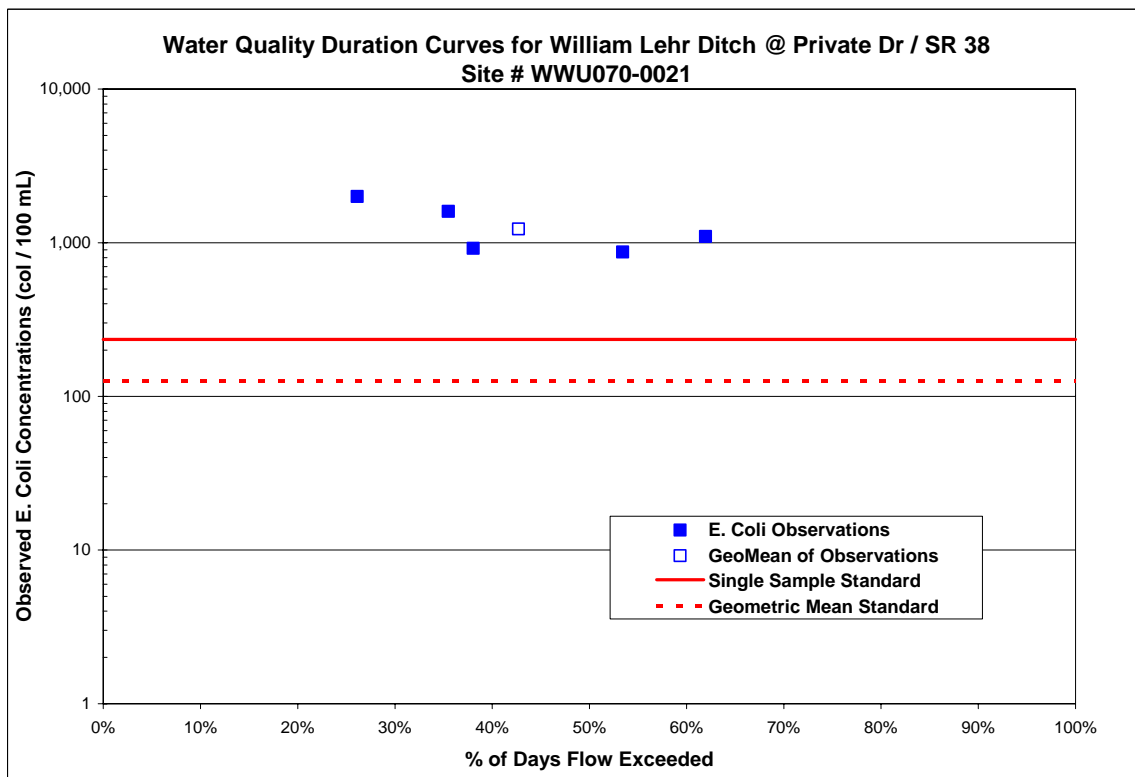
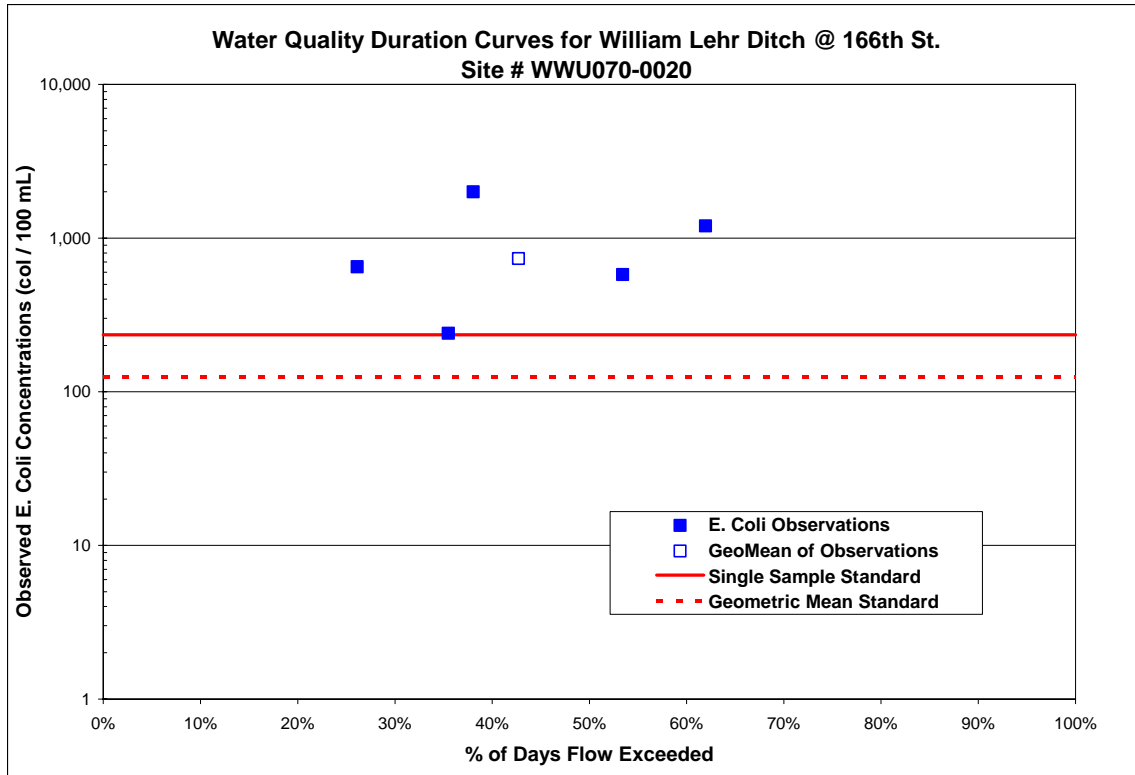


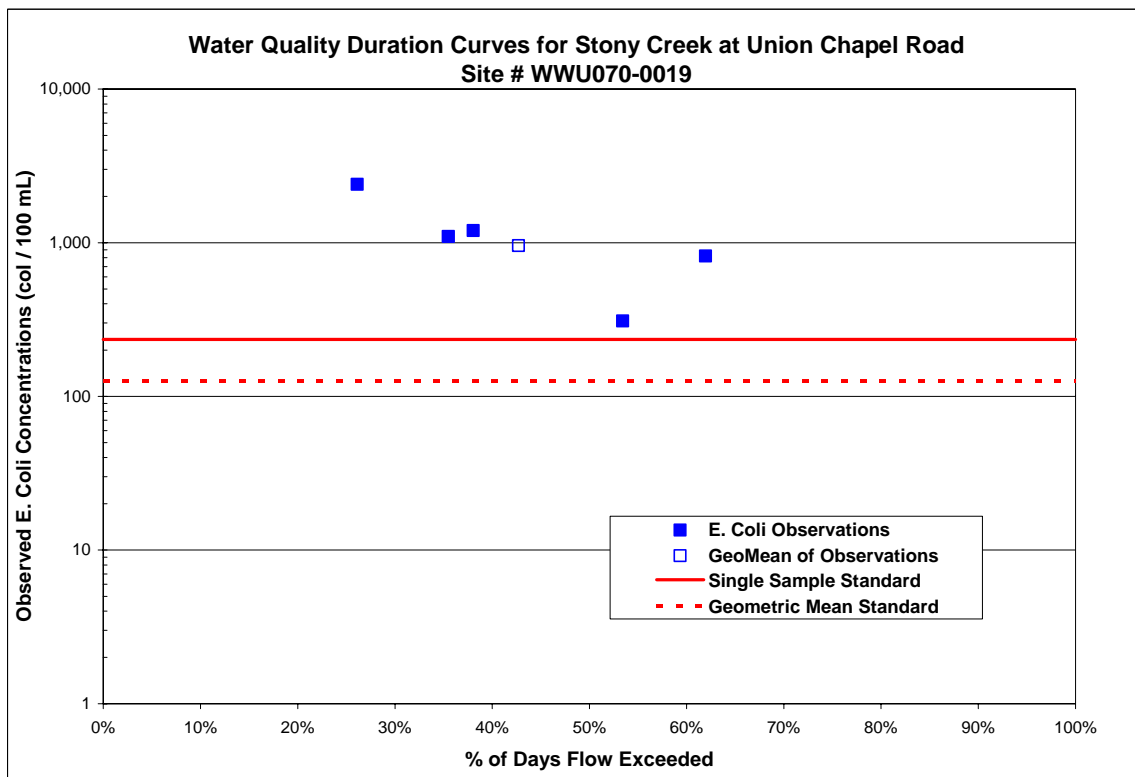
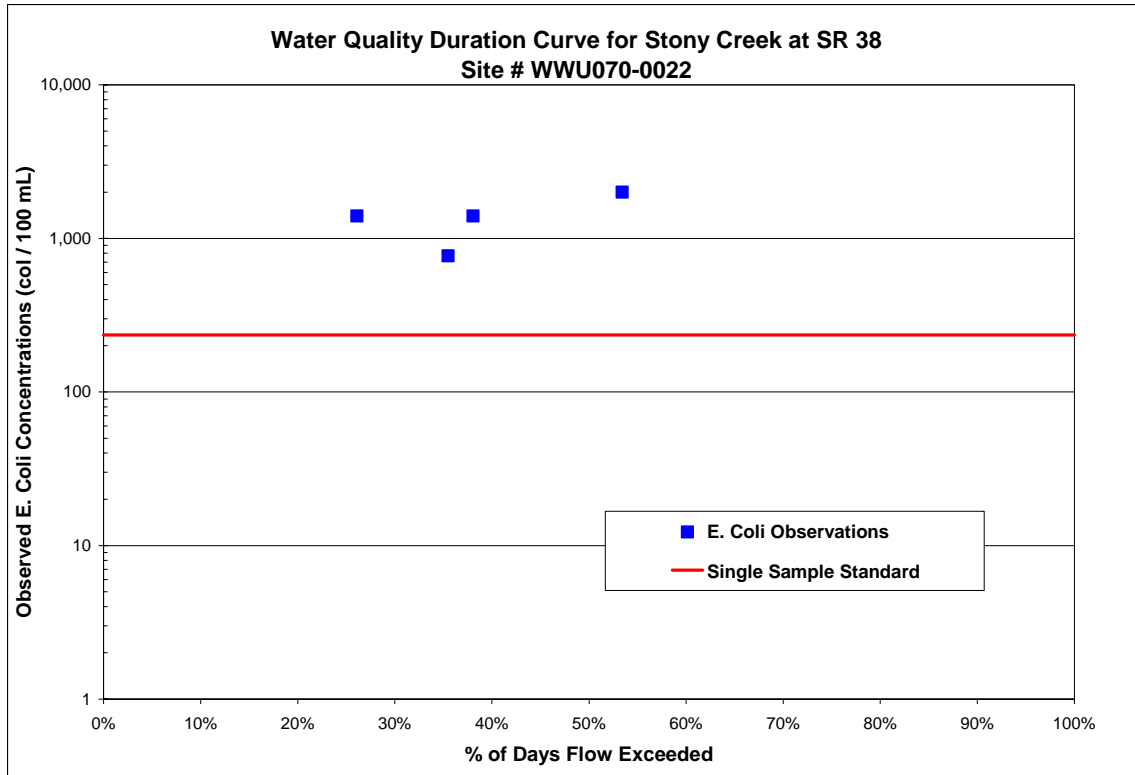


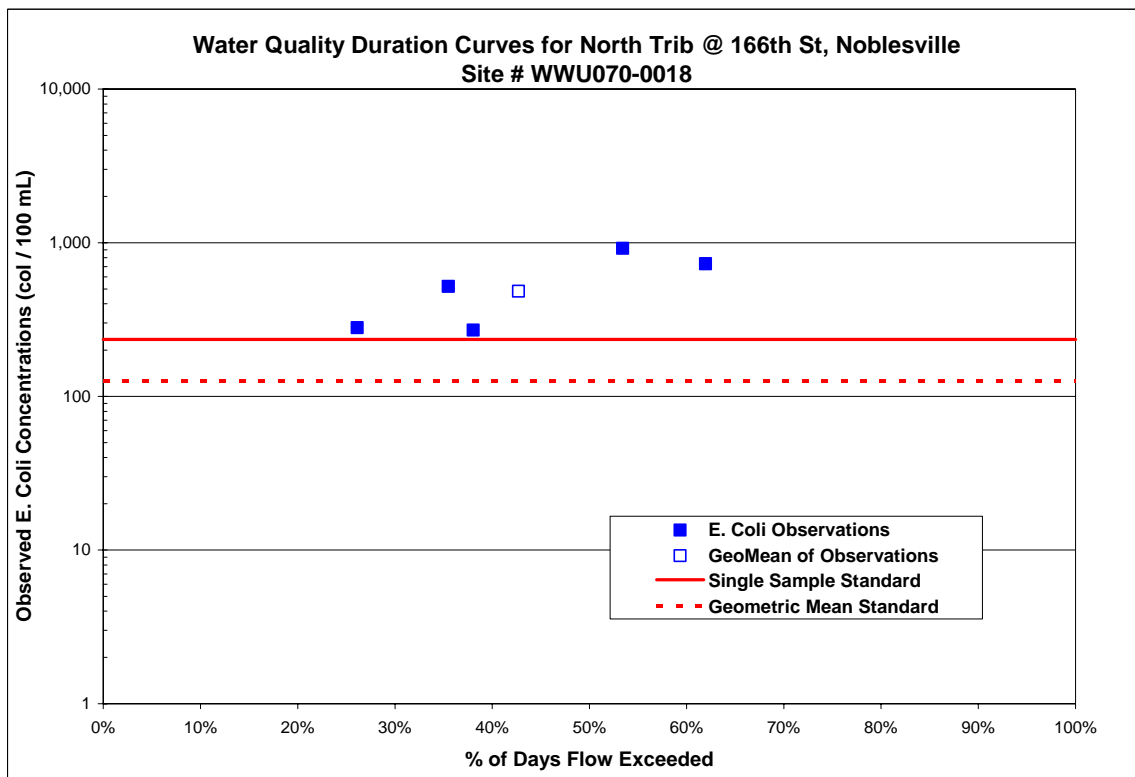
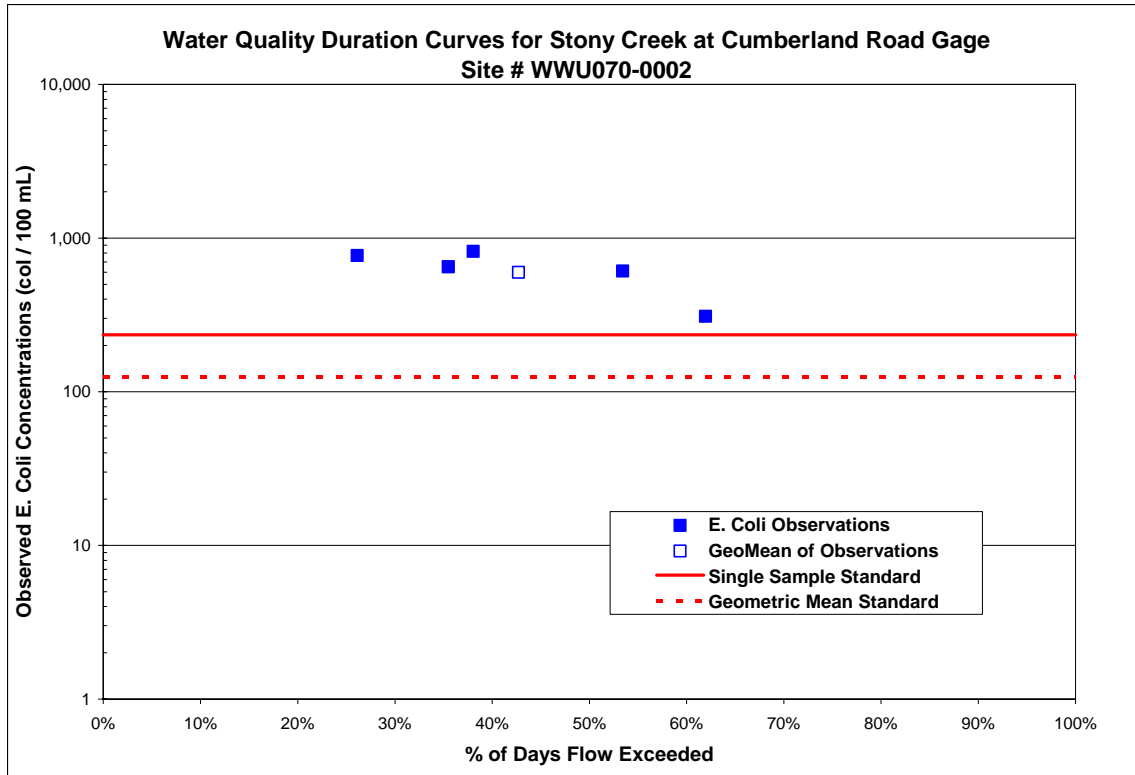


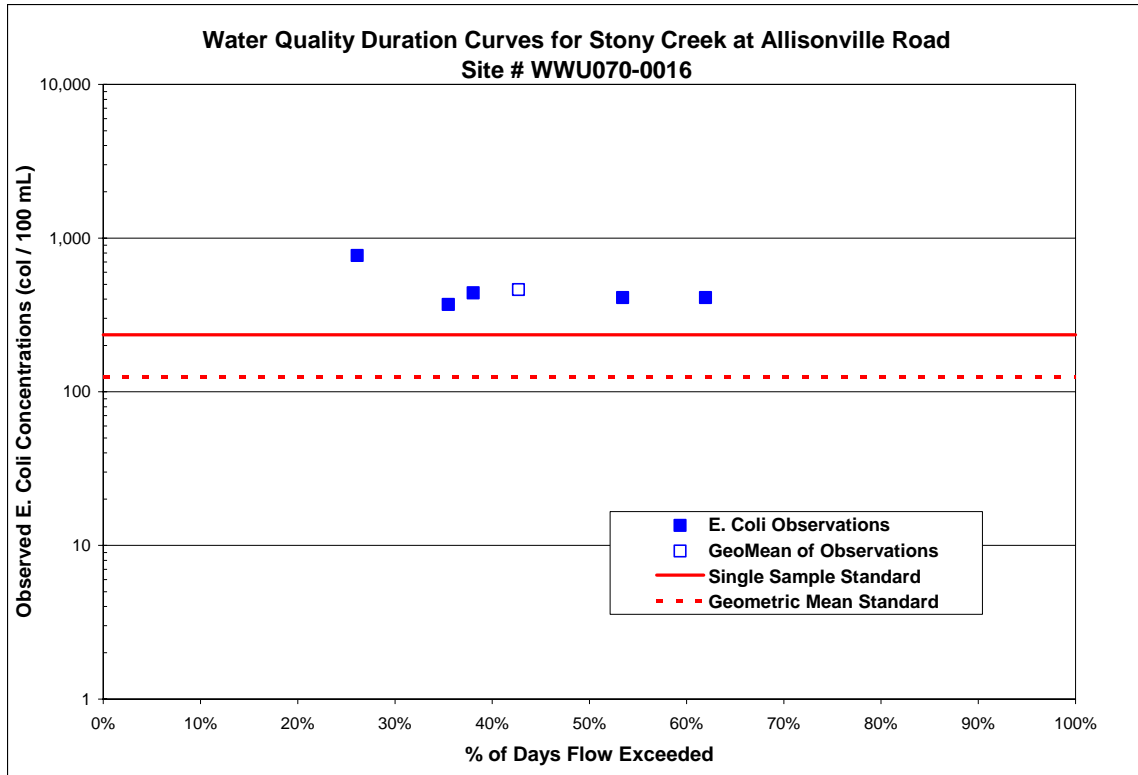












APPENDIX C

INCREMENTAL WATERSHED LDC TABLES AND FIGURES FOR THE DUCK CREEK, KILLBUCK CREEK, AND STONY CREEK TMDLS

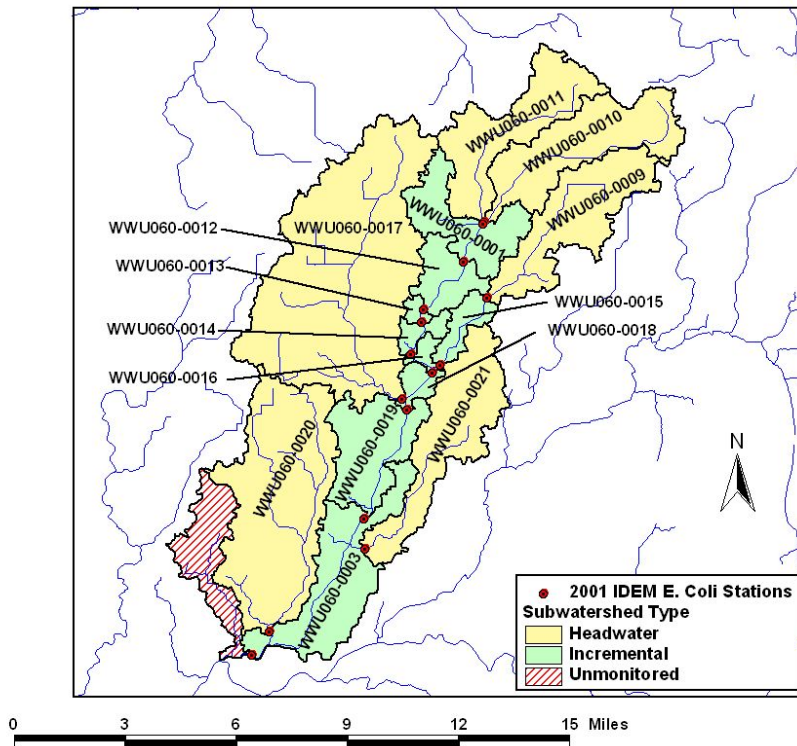


Figure C-1. Subwatersheds Delineated for the Duck Creek Watershed

Table C-1. Subwatershed Statistics for the Duck Creek Watershed

Duck Creek Monitoring Location	Station ID	Subwatershed Area (acres)	Cumulative Area (acres)	Cumulative Drainage Area Ratio to USGS Gage*	Drainage Area Ratio Median Flow (cfs)
CR 1400N	WWU060-0010	5,277	5,277	0.074	2.95
Todd Ditch	WWU060-0011	4,827	4,827	0.067	2.70
CR 1300N	WWU060-0001	3,021	13,125	0.183	7.34
S 9th Street	WWU060-0012	1,683	14,808	0.207	8.28
Elwood WWTP	WWU060-0013	259	15,067	0.211	8.42
CR 1050N	WWU060-0014	562	15,629	0.218	8.74
LDC - Hwy 28	WWU060-0009	5,001	5,001	0.070	2.80
LDC - CR 900W	WWU060-0015	979	5,980	0.084	3.34
CR 1000N	WWU060-0016	347	21,956	0.307	12.28
Polywag Creek	WWU060-0017	16,168	16,168	0.226	9.04
CR 900N	WWU060-0018	593	38,717	0.541	21.65
Hayworth Road	WWU060-0019	3,591	42,308	0.591	23.65
Bear Creek	WWU060-0020	10,184	10,184	0.142	5.69
Lamberson Ditch	WWU060-0021	5,296	5,296	0.074	2.96
SR 213	WWU060-0003	4,990	62,778	0.877	35.10
Unmonitored	-----	2,671	65,449	0.915	36.59

*compared to USGS gage 03348350 (Pipe Creek near Frankton)

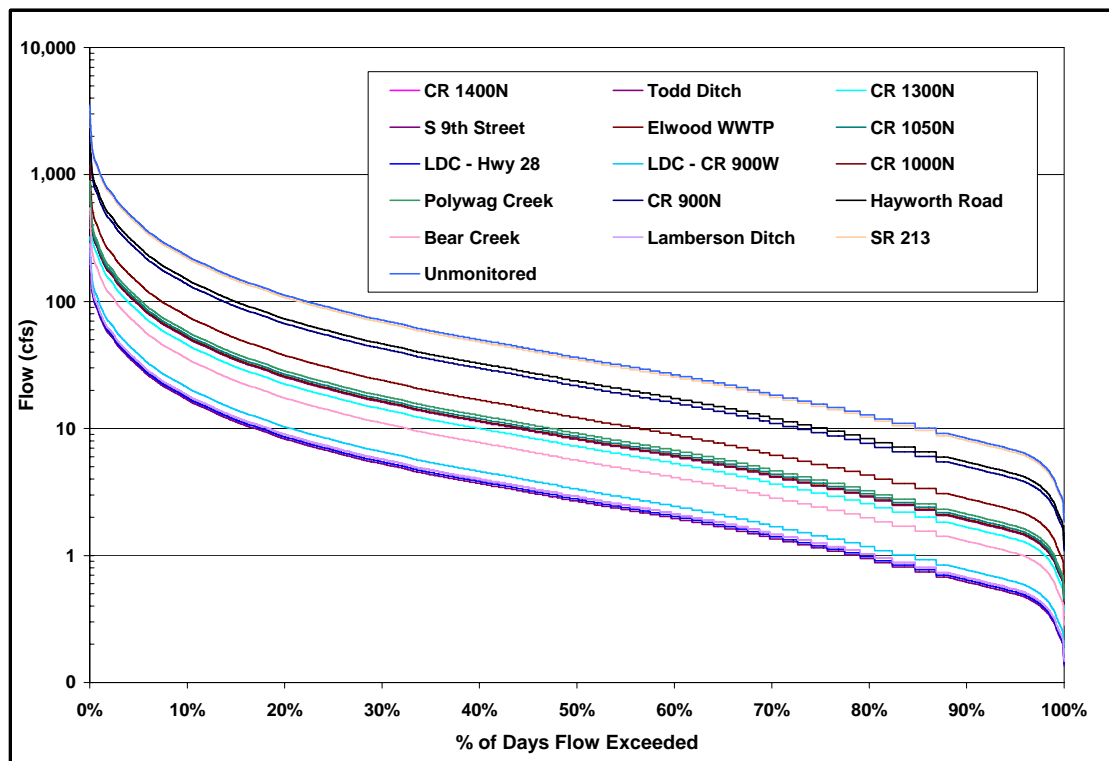


Figure C-2. Flow Duration Curves for Duck Creek Sampling Stations

Table C-2. Duck Creek Composite Curve Number Adjustments and Adjusted Median QDC Flows

Duck Creek Monitoring Location	Station ID	Cumulative Drainage Area Ratio to USGS Gage*	Drainage Area Ratio Median Flow (cfs)	Composite CN Ratio	Adjusted Median QDC Flow (cfs)
CR 1400N	WWU060-0010	0.074	2.95	0.9937	2.93
Todd Ditch	WWU060-0011	0.067	2.70	1.0009	2.70
CR 1300N	WWU060-0001	0.183	7.34	0.9908	7.31
S 9th Street	WWU060-0012	0.207	8.28	1.0250	8.27
Elwood WWTP	WWU060-0013	0.211	8.42	0.9913	8.41
CR 1050N	WWU060-0014	0.218	8.74	1.0050	8.73
LDC - Hwy 28	WWU060-0009	0.070	2.80	1.0023	2.80
LDC - CR 900W	WWU060-0015	0.084	3.34	1.0248	3.36
CR 1000N	WWU060-0016	0.307	12.28	0.9629	12.28
Polywag Creek	WWU060-0017	0.226	9.04	1.0250	9.27
CR 900N	WWU060-0018	0.541	21.65	0.9414	21.86
Hayworth Road	WWU060-0019	0.591	23.65	0.9783	23.82
Bear Creek	WWU060-0020	0.142	5.69	0.9953	5.67
Lamberson Ditch	WWU060-0021	0.074	2.96	0.991	2.93
SR 213	WWU060-0003	0.877	35.10	0.9693	35.13
Unmonitored	-----	0.915	36.59	0.9822	36.59

*compared to USGS gage 03348350 (Pipe Creek near Frankton)

Table C-3. Duck Creek Required Reductions and Allowable Median Loads

Duck Creek Monitoring Location	Station ID	Max E. Coli Concentration (col / 100 mL)	Sample Date	Median QDC Flow (cfs)	Median E. Coli Load (col / day)	Allowable Median Load (col / day)	Required % Reduction	Allowable Incremental Median Load (col / day)
CR 1400N	WWU060-0010	450	07-May-01	2.93	3.23E+10	1.44E+10	55.6%	1.44E+10
Todd Ditch	WWU060-0011	520	23-Apr-01	2.70	3.44E+10	1.32E+10	61.5%	1.32E+10
CR 1300N	WWU060-0001	340	23-Apr-01	7.31	6.08E+10	2.82E+10	53.7%	5.92E+08
S 9th Street	WWU060-0012	10,000	21-May-01	8.27	2.03E+12	4.28E+10	97.9%	1.47E+10
Elwood WWTP	WWU060-0013	9,200	21-May-01	8.41	1.90E+12	4.36E+10	97.7%	7.43E+08
CR 1050N	WWU060-0014	3,900	21-May-01	8.73	8.34E+11	4.38E+10	94.7%	2.46E+08
LDC - Hwy 28	WWU060-0009	1,700	21-May-01	2.80	1.17E+11	1.45E+10	87.6%	1.45E+10
LDC - CR 900W	WWU060-0015	4,400	21-May-01	3.36	3.62E+11	1.65E+10	95.5%	1.96E+09
CR 1000N	WWU060-0016	2,900	21-May-01	12.28	8.72E+11	6.36E+10	92.7%	3.30E+09
Polywag Creek	WWU060-0017	1,600	23-Apr-01	9.27	3.63E+11	3.74E+10	89.7%	3.74E+10
CR 900N	WWU060-0018	1,700	21-May-01	21.86	9.10E+11	1.02E+11	88.8%	6.59E+08
Hayworth Road	WWU060-0019	1,300	14-May-01	23.82	7.58E+11	1.02E+11	86.5%	7.84E+08
Bear Creek	WWU060-0020	3,300	21-May-01	5.67	4.58E+11	2.93E+10	93.6%	2.93E+10
Lamberson Ditch	WWU060-0021	5,500	14-May-01	2.93	3.95E+11	1.52E+10	96.2%	1.52E+10
SR 213	WWU060-0003	1,300	21-May-01	35.12	1.12E+12	1.82E+11	83.7%	3.49E+10
Unmonitored	-----	-----	-----	36.59	-----	1.89E+11	-----	7.60E+09

Table C-4. Duck Creek *E. coli* Load Estimation and Adjustment Process

Initial Estimated Daily Loads (colonies /day)

Source Category	CR 1400N	Todd Ditch	CR 1300N	S 9th Street	Elwood WWTP	CR 1050N	LDC - Hwy 28	LDC - CR900W
Manure Application	1.23E+13	1.13E+13	7.04E+12	1.63E+12	2.20E+11	6.85E+11	1.14E+13	2.70E+11
Active CAFOs	2.25E+12	1.08E+12	0	0	0	0	0	0
Domestic Animals	5.56E+10	5.12E+10	4.37E+10	1.50E+12	2.95E+11	4.24E+11	1.45E+11	7.43E+11
NPDES	0	0	0	0	1.52E+10	0	0	0
Non-CAFO Livestock	6.65E+11	5.13E+11	5.13E+11	7.81E+10	7.81E+10	7.99E+10	7.90E+11	3.31E+10
Failing Septic	2.44E+11	2.22E+11	1.73E+11	6.99E+11	1.25E+11	1.70E+11	5.37E+11	3.72E+11
CSOs	0	0	0	1.11E+12	3.17E+11	0	0	7.94E+11
Wildlife	1.06E+12	9.70E+11	6.07E+11	3.38E+11	5.21E+10	1.13E+11	1.01E+12	1.97E+11
Totals	1.66E+13	1.42E+13	8.38E+12	5.35E+12	1.10E+12	1.47E+12	1.38E+13	2.41E+12

Distance to Station (m)	1972	1972	3120	638	1573	1374	3991	552
Relative Length	1.00	1.00	1.58	0.32	0.80	0.70	2.02	0.28

Subwatershed Factor	513.8	412.3	187.6	2.655	2.9	5.69	118.7	6.91
Downstream Decay	0.242	0.242	0.153	0.748	0.303	0.347	0.120	0.865

Adjusted Daily Loads (colonies / day)

Source Category	CR 1400N	Todd Ditch	CR 1300N	S 9th Street	Elwood WWTP	CR 1050N	LDC - Hwy 28	LDC - CR900W
Manure Application	2.40E+10	2.75E+10	3.75E+10	6.13E+11	7.59E+10	1.20E+11	9.58E+10	3.90E+10
Active CAFOs	4.38E+09	2.63E+09	-----	-----	-----	-----	-----	-----
Domestic Animals	1.08E+08	1.24E+08	2.33E+08	5.64E+11	1.02E+11	7.46E+10	1.22E+09	1.08E+11
NPDES	-----	-----	-----	-----	5.25E+09	-----	-----	-----
Non-CAFO Livestock	1.29E+09	1.24E+09	2.74E+09	2.94E+10	2.69E+10	1.40E+10	6.66E+09	4.79E+09
Failing Septic	4.75E+08	5.37E+08	9.23E+08	2.63E+11	4.31E+10	2.99E+10	4.52E+09	5.38E+10
CSOs	-----	-----	-----	4.19E+11	1.09E+11	-----	-----	1.15E+11
Wildlife	2.06E+09	2.35E+09	3.24E+09	1.27E+11	1.79E+10	1.98E+10	8.47E+09	2.85E+10
Upstream Load	0	0	1.61E+10	9.30E+09	1.51E+12	5.75E+11	0	1.39E+10
Subwatershed sum	3.23E+10	3.44E+10	4.47E+10	2.02E+12	3.80E+11	2.59E+11	1.17E+11	3.49E+11
Cumulative sum	3.23E+10	3.44E+10	6.08E+10	2.02E+12	1.89E+12	8.34E+11	1.17E+11	3.63E+11

Observed Median Load	3.23E+10	3.44E+10	6.08E+10	2.03E+12	1.90E+12	8.34E+11	1.17E+11	3.62E+11
----------------------	----------	----------	----------	----------	----------	----------	----------	----------

Table C-4 (continued). Duck Creek *E. coli* Load Estimation and Adjustment Process

Initial Estimated Daily Loads (colonies / day)

Source Category	CR 1000N	Polywag Creek	CR 900N	Hayworth Road	Bear Creek	Lamberson Ditch	SR 213	Ungaged
Manure Application	3.50E+11	4.98E+13	1.21E+12	9.26E+12	2.58E+13	1.20E+13	1.10E+13	5.98E+12
Active CAFOs	0	1.50E+12	0	1.26E+12	0	0	0	6.28E+11
Domestic Animals	9.79E+10	4.88E+11	2.12E+10	7.07E+10	1.63E+11	2.23E+11	1.19E+11	4.23E+10
NPDES	0	0	0	0	0	0	0	0
Non-CAFO Livestock	2.60E+10	3.49E+12	3.56E+11	1.15E+12	3.16E+12	9.39E+11	1.84E+12	5.69E+11
Failing Septic	5.68E+10	1.15E+12	9.09E+10	2.93E+11	7.10E+11	7.27E+11	5.25E+11	1.85E+11
CSOs	0	0	0	0	0	0	0	0
Wildlife	6.97E+10	3.25E+12	1.19E+11	7.22E+11	2.05E+12	1.06E+12	1.00E+12	5.37E+11
Totals	6.01E+11	5.97E+13	1.79E+12	1.28E+13	3.19E+13	1.50E+13	1.44E+13	7.94E+12

Distance to Station (m)	2172	530	5455	9133	1851	8586	1502	-----
Relative Length	1.10	0.27	2.77	4.63	0.94	4.35	0.76	-----

Subwatershed Factor	2.23	164.5	4.58	18.8	69.7	37.93	15.4	104.25
Downstream Decay	0.220	0.900	0.087	0.052	0.258	0.056	0.318	-----

Adjusted Daily Loads (colonies / day)

Source Category	CR 1000N	Polywag Creek	CR 900N	Hayworth Road	Bear Creek	Lamberson Ditch	SR 213	Ungaged
Manure Application	1.57E+11	3.03E+11	2.63E+11	4.93E+11	3.71E+11	3.17E+11	7.12E+11	5.74E+10
Active CAFOs	-----	9.13E+09	-----	6.73E+10	-----	-----	-----	6.03E+09
Domestic Animals	4.39E+10	2.96E+09	4.63E+09	3.76E+09	2.33E+09	5.88E+09	7.71E+09	4.05E+08
NPDES	-----	-----	-----	-----	-----	-----	-----	-----
Non-CAFO Livestock	1.17E+10	2.12E+10	7.78E+10	6.12E+10	4.53E+10	2.47E+10	1.2E+11	5.46E+09
Failing Septic	2.55E+10	6.99E+09	1.98E+10	1.56E+10	1.02E+10	1.92E+10	3.41E+10	1.77E+09
CSOs	-----	-----	-----	-----	-----	-----	-----	-----
Wildlife	3.13E+10	1.98E+10	2.6E+10	3.84E+10	2.94E+10	2.81E+10	6.51E+10	5.15E+09
Upstream Load	6.03E+11	0	5.18E+11	7.96E+10	0	0	1.8E+11	3.55E+11
Subwatershed sum	2.69E+11	3.63E+11	3.92E+11	6.79E+11	4.58E+11	3.95E+11	9.38E+11	7.62E+10
Cumulative sum	8.72E+11	3.63E+11	9.10E+11	7.58E+11	4.58E+11	3.95E+11	1.12E+12	4.31E+11

Observed Median Load	8.72E+11	3.63E+11	9.1E+11	7.58E+11	4.58E+11	3.95E+11	1.12E+12	-----
----------------------	----------	----------	---------	----------	----------	----------	----------	-------

Table C-5. Duck Creek *E. coli* Load Allocations and Source Category Percent Reductions

Source Category	CR 1400N	Todd Ditch	CR 1300N	S 9th Street	Elwood WWTP	CR 1050N	LDC - Hwy 28	LDC - CR900W
Required % Reduction	55.56%	61.54%	53.68%	97.89%	97.70%	94.74%	87.56%	95.45%
Target Median Load	1.44E+10	1.32E+10	2.82E+10	4.28E+10	4.36E+10	4.38E+10	1.45E+10	1.65E+10

Median Daily Load Allocations (colonies /day)

Source Category	CR 1400N	Todd Ditch	CR 1300N	S 9th Street	Elwood WWTP	CR 1050N	LDC - Hwy 28	LDC - CR900W
Manure Application	8.16E+09	8.53E+09	1.50E+10	6.13E+09	7.59E+08	1.08E+10	9.58E+09	1.95E+09
Active CAFOs	4.38E+09	2.63E+09	-----	-----	-----	-----	-----	-----
Domestic Animals	1.08E+08	1.24E+08	2.33E+08	1.13E+10	2.04E+09	7.46E+09	1.22E+08	5.38E+09
NPDES	-----	-----	-----	-----	5.25E+09	-----	-----	-----
Non-CAFO Livestock	4.40E+08	3.86E+08	1.09E+09	2.94E+08	2.69E+08	1.26E+09	6.66E+08	2.40E+08
Failing Septic	3.33E+08	3.76E+08	9.23E+08	5.26E+09	8.62E+08	2.99E+09	4.52E+08	2.15E+09
CSOs	-----	-----	-----	8.37E+09	2.19E+09	-----	-----	3.45E+09
Wildlife	8.26E+08	9.41E+08	1.29E+09	6.37E+09	8.97E+08	7.94E+09	3.39E+09	1.42E+09
Upstream Load	-----	-----	6.59E+09	3.85E+09	3.11E+10	1.32E+10	-----	1.70E+09
Subwatershed Sum	1.42E+10	1.30E+10	1.86E+10	3.77E+10	1.23E+10	3.05E+10	1.42E+10	1.46E+10
Cumulative Sum	1.42E+10	1.30E+10	2.51E+10	4.16E+10	4.33E+10	4.36E+10	1.42E+10	1.63E+10

Relative % Error	-0.80%	-1.85%	-10.72%	-2.96%	-0.49%	-0.41%	-2.12%	-1.13%
------------------	--------	--------	---------	--------	--------	--------	--------	--------

Subwatershed Percent Reductions

Source Category	CR 1400N	Todd Ditch	CR 1300N	S 9th Street	Elwood WWTP	CR 1050N	LDC - Hwy 28	LDC - CR900W
Manure Application	66%	69%	60%	99%	99%	91%	90%	95%
Active CAFOs	0%	0%	-----	-----	-----	-----	-----	-----
Domestic Animals	0%	0%	0%	98%	98%	90%	90%	95%
NPDES	-----	-----	-----	-----	0%	-----	-----	-----
Non-CAFO Livestock	66%	69%	60%	99%	99%	91%	90%	95%
Failing Septic	30%	30%	0%	98%	98%	90%	90%	96%
CSOs	-----	-----	-----	98%	98%	-----	-----	97%
Wildlife	60%	60%	60%	95%	95%	60%	60%	95%

Table C-5 (continued). Duck Creek *E. coli* Load Allocations and Source Category
Percent Reductions

Source Category	CR 1000N	Polywag Creek	CR 900N	Hayworth Road	Bear Creek	Lamberson Ditch	SR 213	Ungaged
Required % Reduction	92.71%	89.69%	88.82%	86.48%	93.59%	96.15%	83.73%	-----
Target Median Load	6.36E+10	3.74E+10	1.02E+11	1.03E+11	2.93E+10	1.52E+10	1.82E+11	-----

Median Daily Load Allocations (colonies /day)

Source Category	CR 1000N	Polywag Creek	CR 900N	Hayworth Road	Bear Creek	Lamberson Ditch	SR 213	Ungaged
Manure Application	7.85E+09	1.51E+10	2.63E+10	2.46E+10	1.11E+10	6.35E+09	1.07E+11	8.61E+09
Active CAFOs	-----	9.13E+09	-----	4.71E+10	-----	-----	-----	6.03E+09
Domestic Animals	1.10E+10	2.96E+09	4.63E+09	3.76E+09	2.33E+09	1.47E+09	3.86E+09	2.03E+08
NPDES	-----	-----	-----	-----	-----	-----	-----	-----
Non-CAFO Livestock	5.83E+08	1.06E+09	7.78E+09	3.06E+09	1.36E+09	4.95E+08	1.8E+10	8.18E+08
Failing Septic	1.27E+09	4.89E+08	2.98E+09	1.56E+09	2.55E+09	9.58E+08	6.82E+09	7.08E+08
CSOs	-----	-----	-----	-----	-----	-----	-----	-----
Wildlife	1.25E+10	7.90E+09	1.04E+10	1.34E+10	1.17E+10	5.61E+09	2.6E+10	2.06E+09
Upstream Load	2.92E+10	-----	4.68E+10	8.65E+09	-----	-----	1.37E+10	5.56E+10
Subwatershed Sum	3.32E+10	3.67E+10	5.21E+10	9.35E+10	2.91E+10	1.49E+10	1.61E+11	1.84E+10
Cumulative Sum	6.24E+10	3.67E+10	9.89E+10	1.02E+11	2.91E+10	1.49E+10	1.75E+11	7.41E+10

Relative % Error	-1.86%	-1.96%	-2.78%	-0.30%	-0.82%	-2.08%	-3.73%	-----
------------------	--------	--------	--------	--------	--------	--------	--------	-------

Subwatershed Percent Reductions

Source Category	CR 1000N	Polywag Creek	CR 900N	Hayworth Road	Bear Creek	Lamberson Ditch	SR 213	Ungaged
Manure Application	95%	95%	90%	95%	97%	98%	85%	85%
Active CAFOs	-----	0%	-----	30%	-----	-----	-----	0%
Domestic Animals	75%	0%	0%	0%	0%	75%	50%	50%
NPDES	-----	-----	-----	-----	-----	-----	-----	-----
Non-CAFO Livestock	95%	95%	90%	95%	97%	98%	85%	85%
Failing Septic	95%	93%	85%	90%	75%	95%	80%	60%
CSOs	-----	-----	-----	-----	-----	-----	-----	-----
Wildlife	60%	60%	60%	65%	60%	80%	60%	60%

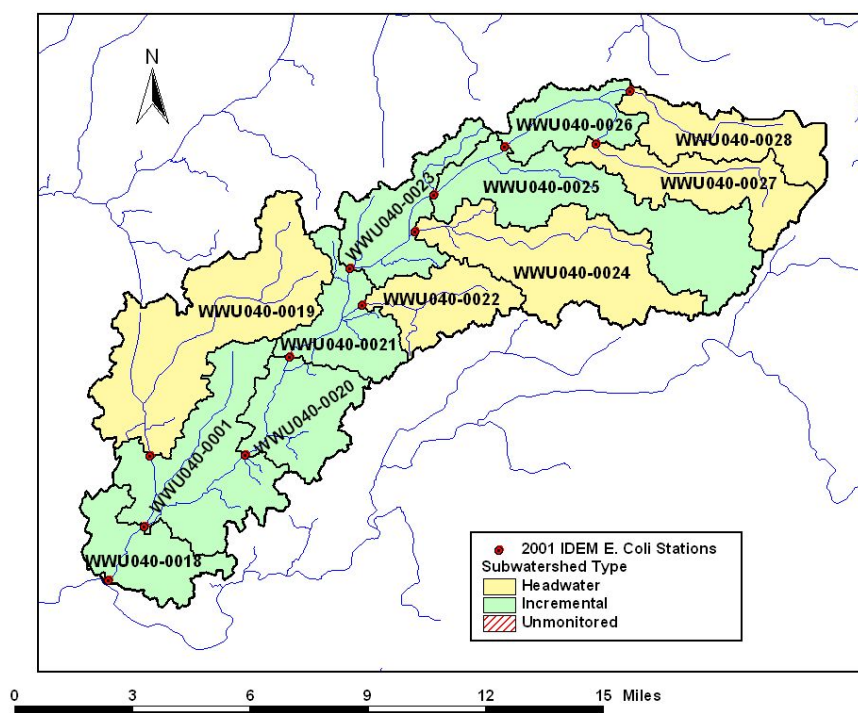


Figure C-3. Subwatersheds Delineated for the Killbuck Creek Watershed

Table C-6. Subwatershed Statistics for the Killbuck Creek Watershed

Killbuck Creek Monitoring Location	Station ID	Subwatershed Area (acres)	Cumulative Area (acres)	Cumulative Drainage Area Ratio to USGS Gage*	Drainage Area Ratio Median Flow (cfs)
Mud Creek	WWU040-0028	4198	4198	0.207	2.48
	WWU040-0027	4621	4621	0.228	2.73
SR28/US 35	WWU040-0026	3057	11876	0.586	7.03
CR 700W	WWU040-0025	8739	20615	1.016	12.20
CR 750W	WWU040-0024	7748	7748	0.382	4.58
NCR 925W	WWU040-0023	4204	32567	1.606	19.27
SR 332	WWU040-0022	3456	3456	0.170	2.04
CR 425E	WWU040-0021	3727	39750	1.960	23.52
CR 400N	WWU040-0020	4304	44054	2.172	26.06
Little Killbuck Creek	WWU040-0019	10991	10991	0.542	6.50
SR 9 Bridge Broadway St.	WWU040-0001	7812	62857	3.099	37.19
	WWU040-0018	3730	66587	3.283	39.40

*compared to USGS Gage 03348020 near Gaston

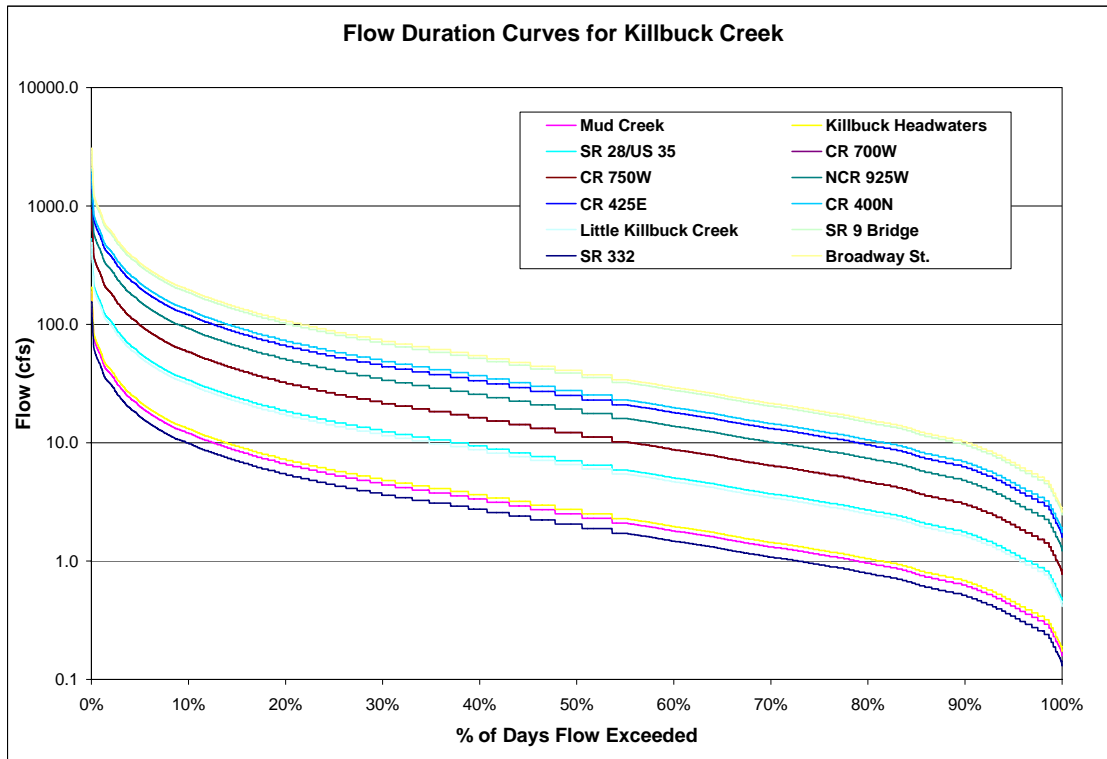


Figure C-4. Flow Duration Curves for Killbuck Creek Sampling Stations

Table C-7. Killbuck Creek Composite Curve Number Adjustments and Adjusted Median QDC Flows

Killbuck Creek Monitoring Location	Station ID	Cumulative Drainage Area Ratio to USGS Gage*	Drainage Area Ratio Median Flow (cfs)	Composite CN Ratio	Adjusted Median QDC Flow (cfs)
Mud Creek	WWU040-0028	0.207	2.48	1.0097	2.51
Killbuck Headwaters	WWU040-0027	0.228	2.73	1.0003	2.73
SR28/US 35	WWU040-0026	0.586	7.03	0.9979	7.05
CR 700W	WWU040-0025	1.016	12.20	0.9962	12.20
CR 750W	WWU040-0024	0.382	4.58	0.9888	4.53
NCR 925W	WWU040-0023	1.606	19.27	1.0101	19.24
SR 332	WWU040-0022	0.170	2.04	1.0055	2.06
CR 425E	WWU040-0021	1.960	23.52	0.9977	23.50
CR 400N	WWU040-0020	2.172	26.06	1.0026	26.05
Little Killbuck Creek	WWU040-0019	0.542	6.50	1.0050	6.53
SR 9 Bridge	WWU040-0001	3.099	37.19	0.9889	37.16
Broadway St.	WWU040-0018	3.283	39.40	0.97	39.30

*compared to USGS Gage 03348020 near Gaston

Table C-8. Killbuck Creek Required Reductions and Allowable Median Loads

Killbuck Creek Monitoring Location	Station ID	Max E. Coli Concentration (col / 100 mL)	Sample Date	Adjusted Median QDC Flow (cfs)	Median E. Coli Load (col / day)	Allowable Median Load (col / day)	Required % Reduction	Allowable Incremental Median Load (col / day)
Mud Creek	WWU040-0028	190	24-Apr-01	2.51	1.17E+10	1.30E+10	0.0%	1.30E+10
Killbuck Headwaters	WWU040-0027	8200	08-May-01	2.73	5.49E+11	1.42E+10	97.4%	1.42E+10
SR 28/US 35	WWU040-0026	2000	24-Apr-01	7.05	3.45E+11	3.65E+10	89.4%	9.35E+09
CR 700W	WWU040-0025	580	08-May-01	12.20	1.73E+11	5.04E+10	70.9%	1.39E+10
CR 750W	WWU040-0024	2400	01-May-01	4.53	2.66E+11	2.35E+10	91.2%	2.35E+10
NCR 925W	WWU040-0023	730	15-May-01	19.24	3.44E+11	9.96E+10	71.0%	2.58E+10
SR 332	WWU040-0022	2400	08-May-01	2.06	1.21E+11	1.06E+10	91.2%	1.06E+10
CR 425E	WWU040-0021	2400	08-May-01	25.06	1.47E+12	1.30E+11	91.2%	1.95E+10
CR 400N	WWU040-0020	2000	08-May-01	27.62	1.35E+12	1.43E+11	89.4%	1.32E+10
Little Killbuck Creek	WWU040-0019	8700	08-May-01	6.53	1.39E+12	3.38E+10	97.6%	3.38E+10
SR 9 Bridge	WWU040-0001	770	08-May-01	38.72	7.30E+11	2.01E+11	72.5%	2.37E+10
Broadway St.	WWU040-0018	610	08-May-01	40.87	6.10E+11	2.12E+11	65.3%	1.11E+10

Table C-9. Killbuck Creek *E. coli* Load Estimation and Adjustment Process

Initial Estimated Daily Loads (colonies /day)

Source Category	Mud Creek	Killbuck Headwaters	SR 28/ US 35	CR 700W	CR 750W	NCR 925W	SR 332	CR 425E	CR 400N	Little Killbuck Creek	SR 9 Bridge	Broadway St.
Manure Application	9.41E+12	8.69E+12	7.00E+12	1.61E+13	1.66E+13	7.66E+12	2.43E+13	8.78E+12	2.35E+13	3.66E+12	5.71E+12	1.42E+13
Active CAFOs	0	0	0	2.57E+12	0	0	0	0	0	0	0	0
Domestic Animals	5.70E+11	1.41E+11	4.89E+11	2.24E+12	3.60E+12	4.21E+10	7.07E+10	2.54E+11	1.41E+11	6.26E+11	2.80E+11	2.11E+11
NPDES	3.48E+08	0	0	0	1.34E+08	1.48E+08	0	0	1.89E+08	2.37E+07	0	5.47E+07
Non-CAFO Livestock	4.36E+11	3.30E+11	4.79E+11	1.77E+12	2.64E+12	8.33E+11	9.61E+11	9.40E+11	1.90E+12	8.35E+11	8.73E+11	2.24E+12
Failing Septic	2.41E+12	2.09E+12	6.45E+11	3.02E+12	3.69E+12	5.11E+11	1.12E+12	6.25E+11	1.17E+12	2.61E+12	4.21E+12	2.27E+12
CSOs	0	0	0	0	0	0	0	0	0	0	0	0
Wildlife	8.44E+11	9.29E+11	6.14E+11	1.76E+12	1.56E+12	8.45E+11	6.95E+11	1.28E+12	8.65E+11	2.21E+12	1.57E+12	7.50E+11
Totals	1.37E+13	1.22E+13	9.23E+12	2.75E+13	2.81E+13	9.89E+12	2.71E+13	1.19E+13	2.76E+13	9.94E+12	1.26E+13	1.97E+13

Distance to Station (m)	5956	7109	3610	5144	3239	5145	4097	5050	5571	2900	2876	-----
Relative Length	1.00	1.19	0.61	0.86	0.54	0.86	0.69	0.85	0.94	0.49	0.48	-----

Subwatershed Factor	170.1	65.45	11.6	36.65	28.25	18.1	40.05	41.3	92.10	17.86	15.43	18.05
Downstream Decay	0.072	0.060	0.119	0.083	0.132	0.083	0.105	0.085	0.077	0.148	0.149	-----

Adjusted Daily Loads (colonies / day)

Source Category	Mud Creek	Killbuck Headwaters	SR 28/ US 35	CR 700W	CR 750W	NCR 925W	SR 332	CR 425E	CR 400N	Little Killbuck Creek	SR 9 Bridge	Broadway St.
Manure Application	5.53E+10	1.33E+11	6.03E+11	4.40E+11	5.89E+11	4.23E+11	6.07E+11	2.13E+11	2.55E+11	2.05E+11	3.7E+11	7.89E+11
Active CAFOs	0	0	0	7.01E+10	0	0	0	0	0	0	0	0
Domestic Animals	3.35E+09	2.16E+09	4.22E+10	6.11E+10	1.27E+11	2.33E+09	1.77E+09	6.16E+09	1.54E+09	3.51E+10	1.81E+10	1.17E+10
NPDES	2044588	0	0	0	4.74E+06	8.16E+06	0	0	2.06E+06	1.32E+06	0	3.03E+06
Non-CAFO Livestock	2.56E+09	5.05E+09	4.13E+10	4.84E+10	9.36E+10	4.60E+10	2.40E+10	2.28E+10	2.07E+10	4.68E+10	5.66E+10	1.24E+11
Failing Septic	1.42E+10	3.19E+10	5.56E+10	8.23E+10	1.31E+11	2.82E+10	2.80E+10	1.51E+10	1.27E+10	1.46E+11	2.73E+11	1.26E+11
CSOs	0	0	0	0	0	0	0	0	0	0	0	0
Wildlife	4.96E+09	1.42E+10	5.30E+10	4.79E+10	5.51E+10	4.67E+10	1.73E+10	3.10E+10	9.39E+09	1.24E+11	1.02E+11	4.15E+10
Upstream Load	0	0	1.70E+10	9.65E+10	0	2.02E+11	0	1.33E+11	3.57E+10	0	1.08E+11	1.38E+11
Subwatershed sum	8.04E+10	1.86E+11	7.95E+11	7.50E+11	9.95E+11	5.46E+11	6.78E+11	2.88E+11	3.00E+11	5.57E+11	8.19E+11	1.09E+12
Cumulative sum	8.04E+10	1.86E+11	8.12E+11	8.46E+11	9.95E+11	7.48E+11	6.78E+11	4.21E+11	3.35E+11	5.57E+11	9.27E+11	1.23E+12

Observed Median Load	8.04E+10	1.86E+11	8.12E+11	8.46E+11	9.95E+11	7.48E+11	6.78E+11	4.21E+11	3.35E+11	5.57E+11	9.27E+11	1.23E+12
----------------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------

Table C-10. Killbuck Creek *E. coli* Load Allocations and Source Category Percent Reductions

Source Category	Mud Creek	Killbuck Headwaters	SR 28/ US 35	CR 700W	CR 750W	NCR 925W	SR 332	CR 425E	CR 400N	Little Killbuck Creek	SR 9 Bridge	Broadway St.
Required % Reduction	0.00%	97.42%	89.43%	70.90%	91.19%	71.03%	91.19%	91.19%	89.43%	97.57%	72.53%	65.33%
Target Median Load	8.04E+10	4.80E+09	8.41E+10	2.18E+11	8.77E+10	1.58E+11	5.97E+10	2.53E+10	3.17E+10	1.35E+10	2.25E+11	3.78E+11

Median Daily Load Allocations (colonies /day)

Source Category	Mud Creek	Killbuck Headwaters	SR 28/ US 35	CR 700W	CR 750W	NCR 925W	SR 332	CR 425E	CR 400N	Little Killbuck Creek	SR 9 Bridge	Broadway St.
Manure Application	5.53E+10	2.65E+09	5.43E+10	6.60E+10	4.71E+10	9.31E+10	4.85E+10	4.25E+09	2.30E+10	2.05E+09	9.26E+10	2.37E+11
Active CAFOs	-----	-----	-----	7.01E+10	-----	-----	-----	-----	-----	-----	-----	-----
Domestic Animals	3.35E+09	4.32E+07	3.80E+09	2.44E+10	1.02E+10	6.98E+08	1.41E+08	1.85E+08	4.61E+08	3.15E+09	5.26E+09	3.97E+09
NPDES	2044588	-----	-----	-----	4.74E+06	8.16E+06	-----	-----	2.06E+06	1.32E+06	-----	3.03E+06
Non-CAFO Livestock	2.56E+09	1.01E+08	3.72E+09	7.26E+09	7.49E+09	1.01E+10	1.92E+09	4.55E+08	1.86E+09	4.68E+08	1.41E+10	3.72E+10
Failing Septic	1.42E+10	1.60E+09	1.11E+10	2.06E+10	1.31E+10	7.06E+09	2.80E+09	4.54E+08	1.91E+09	1.46E+09	7.91E+10	4.27E+10
CSOs	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Wildlife	4.96E+09	2.84E+08	4.77E+09	1.92E+10	8.27E+09	1.40E+10	5.20E+09	9.31E+08	1.88E+09	6.18E+09	2.95E+10	1.87E+10
Upstream Load	0	0	6.07E+09	9.95E+09	0	2.95E+10	0	1.90E+10	2.15E+09	0	4.37E+09	3.35E+10
Subwatershed Sum	8.04E+10	4.68E+09	7.77E+10	2.08E+11	8.61E+10	1.25E+11	5.86E+10	6.28E+09	2.91E+10	1.33E+10	2.21E+11	3.39E+11
Cumulative Sum	8.04E+10	4.68E+09	8.38E+10	2.17E+11	8.61E+10	1.54E+11	5.86E+10	2.53E+10	3.12E+10	1.33E+10	2.25E+11	3.73E+11

Relative % Error	0.00%	-2.50%	-0.41%	-0.32%	-1.84%	-2.39%	-1.89%	-0.25%	-1.42%	-1.59%	-0.07%	-1.52%
------------------	-------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

Subwatershed Percent Reductions

Source Category	Mud Creek	Killbuck Headwaters	SR 28/ US 35	CR 700W	CR 750W	NCR 925W	SR 332	CR 425E	CR 400N	Little Killbuck Creek	SR 9 Bridge	Broadway St.
Manure Application	0%	98%	91%	85%	92%	78%	92%	98%	91%	99%	75%	70%
Active CAFOs	-----	-----	-----	0%	-----	-----	-----	-----	-----	-----	-----	-----
Domestic Animals	0%	98%	91%	60%	92%	70%	92%	97%	70%	91%	71%	66%
NPDES	0%	-----	-----	-----	0%	0%	-----	-----	0%	0%	-----	0%
Non-CAFO Livestock	0%	98%	91%	85%	92%	78%	92%	98%	91%	99%	75%	70%
Failing Septic	0%	95%	80%	75%	90%	75%	90%	97%	85%	99%	71%	66%
CSOs	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Wildlife	0%	98%	91%	60%	85%	70%	70%	97%	80%	95%	71%	55%

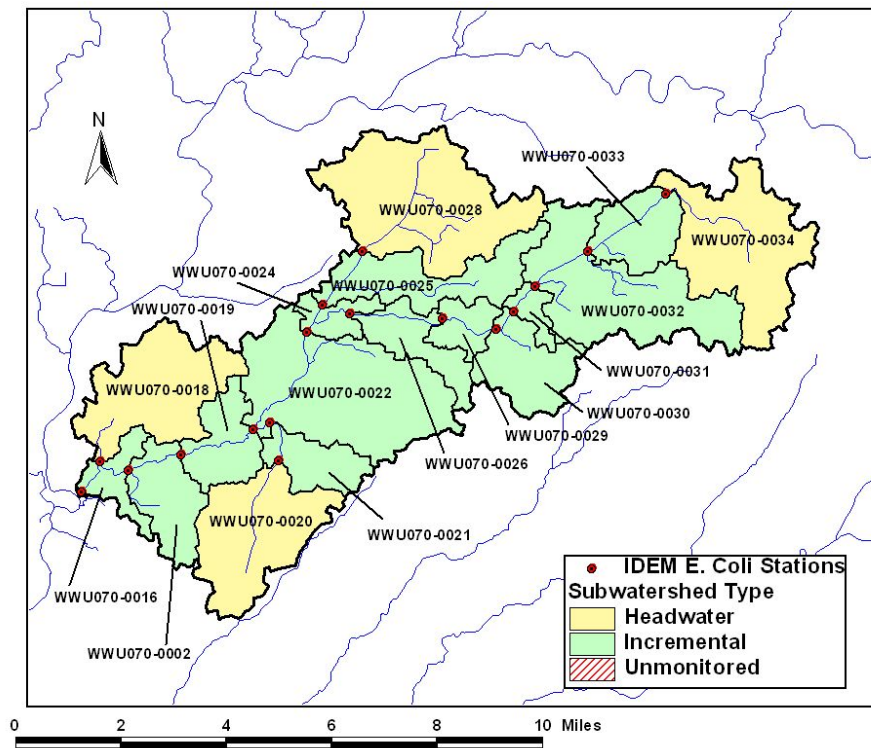


Figure C-5. Subwatersheds Delineated for the Stony Creek Watershed

Table C-11. Subwatershed Statistics for the Stony Creek Watershed

Stony Creek Monitoring Location	Station ID	Subwatershed Area (acres)	Cumulative Area (acres)	Cumulative Drainage Area Ratio to USGS Gage*	Drainage Area Ratio Median Flow (cfs)
CR 650 W	WWU070-0034	3660	3660	0.115	2.65
CR 825 W	WWU070-0033	1362	5023	0.158	3.63
CR 925 W	WWU070-0032	3910	8933	0.281	6.46
SR 132/13	WWU070-0031	386	9319	0.293	6.74
CR 1000 W	WWU070-0030	1628	10947	0.344	7.92
Cyntheanne Rd	WWU070-0029	679	11627	0.366	8.41
70-0026	WWU070-0026	1151	12778	0.402	9.24
Wm Lock E206th/Durbin Rd	WWU070-0028	4580	4580	0.144	3.31
Wm Lock Ditch @ E196th	WWU070-0025	2160	6740	0.212	4.88
E 196th St	WWU070-0024	582	20099	0.632	14.54
Wm Lehr Ditch @ 166th	WWU070-0020	2998	2998	0.094	2.17
Wm Lehr @ Private Dr/SR 38	WWU070-0021	1059	4057	0.128	2.93
SR 38	WWU070-0022	4860	29016	0.913	20.99
Union Chapel Rd	WWU070-0019	1309	30325	0.954	21.94
Cumberland Rd Gage	WWU070-0002	1467	31792	1.000	23.00
North Trib @ 166th Noblesville	WWU070-0018	3059	3059	0.096	2.21
Allisonville Rd.	WWU070-0016	723	35573	1.119	25.74

* compared to USGS Gage 03350700 near Noblesville

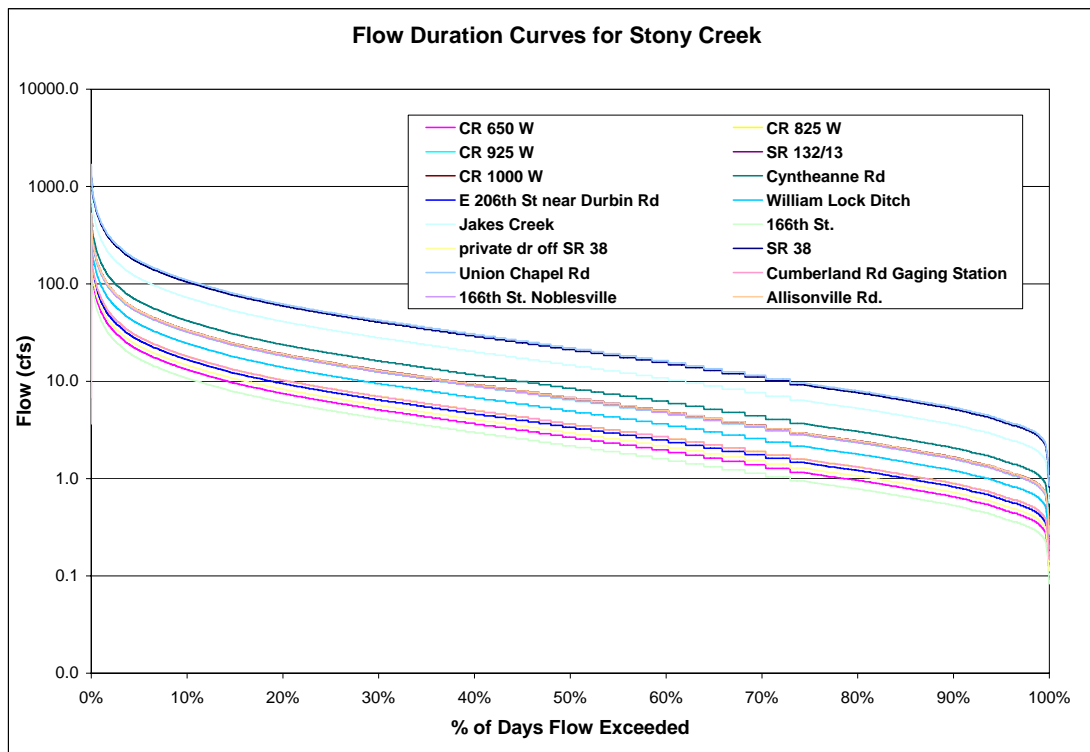


Figure C-6. Flow Duration Curves for Stony Creek Sampling Stations

Table C-12. Stony Creek Composite Curve Number Adjustments and Adjusted Median QDC Flows

Stony Creek Monitoring Location	Station ID	Cumulative Drainage Area Ratio to USGS Gage*	Drainage Area Ratio Median Flow (cfs)	Composite CN Ratio	Adjusted Median QDC Flow (cfs)
CR 650 W	WWU070-0034	0.115	2.65	1.0056	2.66
CR 825 W	WWU070-0033	0.158	3.63	0.9976	3.65
CR 925 W	WWU070-0032	0.281	6.46	1.0094	6.50
SR 132/13	WWU070-0031	0.293	6.74	0.9626	6.77
CR 1000 W	WWU070-0030	0.344	7.92	1.0168	7.97
Cyntheanne Rd	WWU070-0029	0.366	8.41	1.0075	8.46
70-0026	WWU070-0026	0.402	9.24	1.0063	9.30
Wm Lock E206th/Durbin Rd	WWU070-0028	0.144	3.31	1.0170	3.37
Wm Lock Ditch @ E196th	WWU070-0025	0.212	4.88	1.0123	4.95
E 196th St	WWU070-0024	0.632	14.54	0.9424	14.65
Wm Lehr Ditch @ 166th	WWU070-0020	0.094	2.17	1.0016	2.17
Wm Lehr @ Private Dr/SR 38	WWU070-0021	0.128	2.93	1.0141	2.95
SR 38	WWU070-0022	0.913	20.99	1.0124	21.16
Union Chapel Rd	WWU070-0019	0.954	21.94	0.9917	22.10
Cumberland Rd Gage	WWU070-0002	1.000	23.00	0.9965	23.15
North Trib @ 166th Noblesville	WWU070-0018	0.096	2.21	1.0190	2.25
Allisonville Rd.	WWU070-0016	1.119	25.74	1.0046	25.93

* compared to USGS Gage 03350700 near Noblesville

Table C-13. Stony Creek Required Reductions and Allowable Median Loads

Stony Creek Monitoring Location	Station ID	Max E. Coli Concentration (col / 100 mL)	Sample Date	Adjusted Median QDC Flow (cfs)	Median E. Coli Load (col / day)	Allowable Median Load (col / day)	Required % Reduction	Allowable Incremental Median Load (col / day)
CR 650 W	WWU070-0034	580	05-Jun-01	2.66	3.78E+10	1.04E+10	72.4%	1.04E+10
CR 825 W	WWU070-0033	980	19-Jun-01	3.65	8.75E+10	1.19E+10	86.4%	1.45E+09
CR 925 W	WWU070-0032	2400	03-Jul-01	6.50	3.82E+11	3.37E+10	91.2%	2.18E+10
SR 132/13	WWU070-0031	2400	26-Jun-01	6.77	3.98E+11	3.51E+10	91.2%	1.39E+09
CR 1000 W	WWU070-0030	2400	26-Jun-01	7.97	4.68E+11	3.90E+10	91.7%	3.96E+09
Cyntheanne Rd	WWU070-0029	1700	26-Jun-01	8.46	3.52E+11	4.06E+10	88.5%	1.53E+09
70-0026	WWU070-0026	1400	19-Jun-01	9.30	3.19E+11	4.82E+10	84.9%	7.61E+09
Wm Lock E206th/Durbin Rd	WWU070-0028	2400	26-Jun-01	3.37	1.98E+11	1.75E+10	91.2%	1.75E+10
Wm Lock Ditch @ E196th	WWU070-0025	1300	03-Jul-01	4.95	1.58E+11	2.42E+10	84.6%	6.80E+09
E 196th St	WWU070-0024	2000	12-Jun-01	14.65	7.17E+11	7.28E+10	89.9%	3.99E+08
Wm Lehr Ditch @ 166th	WWU070-0020	2000	19-Jun-01	2.17	1.06E+11	1.09E+10	89.8%	1.09E+10
Wm Lehr @ Private Dr/SR 38	WWU070-0021	2000	05-Jun-01	2.95	1.44E+11	1.32E+10	90.9%	2.30E+09
SR 38	WWU070-0022	2000	26-Jun-01	21.16	1.04E+12	8.65E+10	91.7%	4.93E+08
Union Chapel Rd	WWU070-0019	2400	05-Jun-01	22.10	1.30E+12	8.68E+10	93.3%	3.23E+08
Cumberland Rd Gage	WWU070-0002	820	19-Jun-01	23.15	4.65E+11	8.72E+10	81.2%	3.57E+08
North Trib @ 166th Noblesville	WWU070-0018	920	26-Jun-01	2.25	5.08E+10	1.17E+10	77.0%	1.17E+10
Allisonville Rd.	WWU070-0016	770	05-Jun-01	25.93	4.89E+11	1.19E+11	75.6%	2.02E+10

Table C-14. Stony Creek *E. coli* Load Estimation and Adjustment Process

Initial Estimated Daily Loads (colonies /day)

Source Category	CR 650 W	CR 825 W	CR 925 W	SR 132/13	CR 1000 W	Cyntheanne Rd	70-0026	Wm Lock E206th/ Durbin Rd	Wm Lock Ditch @ E196th
Manure Application	8.66E+12	3.19E+12	9.06E+12	2.92E+11	3.38E+12	1.24E+12	2.55E+12	1.04E+13	5.04E+12
Active CAFOs	0	0	2.82E+12	0	0	0	0	1.48E+12	0
Domestic Animals	1.97E+11	3.46E+10	3.28E+11	1.73E+11	2.90E+11	2.86E+10	3.77E+10	1.52E+11	7.07E+10
NPDES	0	0	0	2.06E+09	2.37E+08	0	5.96E+07	0	0
Non-CAFO Livestock	9.01E+11	2.71E+11	7.30E+11	2.36E+10	1.84E+11	9.84E+10	1.31E+11	2.57E+11	2.18E+11
Failing Septic CSOs	8.01E+11	1.59E+11	5.45E+11	8.52E+10	2.56E+11	9.94E+10	1.70E+11	6.76E+11	3.15E+11
Wildlife	7.36E+11	2.74E+11	7.86E+11	7.76E+10	3.27E+11	1.37E+11	2.31E+11	9.20E+11	4.34E+11
Totals	1.13E+13	3.93E+12	1.43E+13	6.54E+11	4.43E+12	1.60E+12	3.12E+12	1.38E+13	6.08E+12

Distance to Station (m)	3011	1995	1076	867	1938	3113	1442	2096	949
Relative Length	1.00	0.66	0.36	0.29	0.64	1.03	0.48	0.70	0.32

Subwatershed Factor	140.5	21.65	17.93	0.913	5.355	2.42	4.9	32.89	20.23
Downstream Decay	0.057	0.086	0.160	0.198	0.089	0.055	0.119	0.082	0.181

Adjusted Daily Loads (colonies / day)

Source Category	CR 650 W	CR 825 W	CR 925 W	SR 132/13	CR 1000 W	Cyntheanne Rd	70-0026	Wm Lock E206th/ Durbin Rd	Wm Lock Ditch @ E196th
Manure Application	6.16E+10	1.47E+11	5.05E+11	3.20E+11	6.30E+11	5.11E+11	5.20E+11	3.15E+11	2.49E+11
Active CAFOs	-----	-----	1.57E+11	-----	-----	-----	-----	4.51E+10	-----
Domestic Animals	1.40E+09	1.60E+09	1.83E+10	1.90E+11	5.42E+10	1.18E+10	7.69E+09	4.62E+09	3.50E+09
NPDES	-----	-----	-----	2.25E+09	4.42E+07	-----	1.22E+07	-----	-----
Non-CAFO Livestock	6.41E+09	1.25E+10	4.07E+10	2.58E+10	3.44E+10	4.07E+10	2.68E+10	7.80E+09	1.08E+10
Failing Septic CSOs	5.70E+09	7.35E+09	3.04E+10	9.33E+10	4.77E+10	4.11E+10	3.48E+10	2.06E+10	1.56E+10
Wildlife	5.24E+09	1.26E+10	4.38E+10	8.50E+10	6.11E+10	5.64E+10	4.72E+10	2.80E+10	2.15E+10
Upstream Load	0	4.582E+09	1.60E+10	1.29E+11	1.674E+11	8.81E+10	4.13E+10	0	3.45E+10
Subwatershed sum	8.04E+10	1.81E+11	7.96E+11	7.16E+11	8.28E+11	6.61E+11	6.36E+11	4.21E+11	3.01E+11
Cumulative sum	8.04E+10	1.86E+11	8.12E+11	8.46E+11	9.95E+11	7.49E+11	6.78E+11	4.21E+11	3.35E+11
Observed Median Load	8.04E+10	1.86E+11	8.12E+11	8.46E+11	9.95E+11	7.49E+11	6.78E+11	4.21E+11	3.35E+11

Table C-14 (continued). Stony Creek *E. coli* Load Estimation and Adjustment Process

Initial Estimated Daily Loads (colonies /day)

Source Category	E 196th St	Wm Lehr Ditch @ 166th	Wm Lehr @ Private Dr /SR 38	SR 38	Union Chapel Rd	Cumberland Rd Gage	North Trib @ 166th Noblesville	Allisonville Rd.
Manure Application	1.34E+12	1.08E+13	2.49E+12	3.25E+12	6.90E+12	2.40E+12	5.17E+12	1.20E+12
Active CAFOs	0	0	0	0	0	0	0	0
Domestic Animals	2.12E+10	1.76E+11	1.52E+11	3.43E+11	4.77E+11	4.06E+10	1.95E+12	2.54E+11
NPDES	0	0	0	0	0	0	2.58E+07	0
Non-CAFO Livestock	8.97E+10	7.74E+11	2.40E+11	5.61E+11	6.05E+11	2.18E+11	2.83E+11	1.31E+11
Failing Septic	9.66E+10	1.15E+12	1.73E+11	7.70E+11	7.16E+11	1.69E+12	1.15E+12	8.15E+11
CSOs	0	0	0	0	0	0	1.31E+12	0
Wildlife	1.17E+11	9.77E+11	2.63E+11	2.95E+11	6.02E+11	2.13E+11	6.15E+11	1.45E+11
Totals	1.67E+12	1.38E+13	3.32E+12	5.21E+12	9.30E+12	4.56E+12	1.05E+13	2.55E+12

Distance to Station (m)	3940	1432	558	2691	1822	1049	1085	
Relative Length	1.31	0.48	0.19	0.89	0.61	0.35	0.36	0

Subwatershed Factor	4.02	14.92	3.03	60	47.35	15.98	97	27.00
Downstream Decay	0.044	0.120	0.308	0.064	0.094	0.164	0.158	-----

Adjusted Daily Loads (colonies / day)

Source Category	E 196th St	Wm Lehr Ditch @ 166th	Wm Lehr @ Private Dr /SR 38	SR 38	Union Chapel Rd	Cumberland Rd Gage	North Trib @ 166th Noblesville	Allisonville Rd.
Manure Application	3.35E+11	7.21E+11	8.22E+11	5.41E+10	1.46E+11	1.50E+11	5.33E+10	4.45E+10
Active CAFOs	-----	-----	-----	-----	-----	-----	-----	-----
Domestic Animals	5.28E+09	1.18E+10	5.01E+10	5.72E+09	1.01E+10	2.54E+09	2.01E+10	9.42E+09
NPDES	-----	-----	-----	-----	-----	-----	2.66E+05	-----
Non-CAFO Livestock	2.23E+10	5.19E+10	7.91E+10	9.35E+09	1.28E+10	1.36E+10	2.92E+09	4.87E+09
Failing Septic	2.40E+10	7.71E+10	5.72E+10	1.28E+10	1.51E+10	1.06E+11	1.19E+10	3.02E+10
CSOs	-----	-----	-----	-----	-----	-----	1.35E+10	-----
Wildlife	2.91E+10	6.55E+10	8.68E+10	4.91E+09	1.27E+10	1.33E+10	6.34E+09	5.38E+09
Upstream Load	1.41E+11	0	1.35E+11	3.78E+11	2.97E+10	2.13E+10	0	1.71E+10
Subwatershed sum	4.15E+11	9.27E+11	1.09E+12	8.69E+10	1.96E+11	2.86E+11	1.08E+11	9.44E+10
Cumulative sum	5.57E+11	9.27E+11	1.23E+12	4.65E+11	2.26E+11	3.07E+11	1.08E+11	1.11E+11
Observed Median Load	5.57E+11	9.27E+11	1.23E+12	4.65E+11	2.26E+11	3.07E+11	1.08E+11	1.11E+11

Table C-15. Stony Creek *E. coli* Load Allocations and Source Category Percent Reductions

Source Category	CR 650 W	CR 825 W	CR 925 W	SR 132/13	CR 1000 W	Cyntheanne Rd	70-0026	Wm Lock E206th/ Durbin Rd	Wm Lock Ditch @ E196th
Required % Reduction	72.41%	86.42%	91.19%	91.19%	91.67%	88.49%	84.89%	91.19%	84.62%
Target Median Load	2.22E+10	2.46E+10	7.01E+10	6.31E+10	6.90E+10	7.61E+10	9.62E+10	3.71E+10	4.62E+10

Median Daily Load Allocations (colonies /day)

Source Category	CR 650 W	CR 825 W	CR 925 W	SR 132/13	CR 1000 W	Cyntheanne Rd	70-0026	Wm Lock E206th/ Durbin Rd	Wm Lock Ditch @ E196th
Manure Application	1.54E+10	1.62E+10	5.05E+09	2.24E+10	5.04E+10	4.09E+10	7.28E+10	1.57E+10	3.24E+10
Active CAFOs	-----	-----	6.28E+10	-----	-----	-----	-----	1.80E+10	-----
Domestic Animals	5.61E+08	4.79E+08	1.83E+08	1.90E+10	4.88E+09	3.55E+09	1.54E+09	2.31E+08	1.05E+09
NPDES	-----	-----	-----	2.25E+09	4.42E+07	-----	1.22E+07	-----	-----
Non-CAFO Livestock	1.60E+09	1.38E+09	4.07E+08	1.81E+09	2.75E+09	3.25E+09	3.76E+09	3.90E+08	1.40E+09
Failing Septic CSOs	2.28E+09	2.20E+09	3.04E+08	8.40E+09	4.30E+09	1.03E+10	6.96E+09	1.03E+09	4.67E+09
Wildlife	2.09E+09	3.79E+09	4.38E+08	8.50E+09	5.50E+09	1.69E+10	9.44E+09	1.40E+09	6.44E+09
Upstream Load	0	1.251E+09	2.18E+09	1.14E+10	1.46E+10	7.31E+09	4.53E+09	0	3.01E+09
Subwatershed Sum	2.19E+10	2.41E+10	6.92E+10	6.23E+10	6.79E+10	7.49E+10	9.45E+10	3.68E+10	4.60E+10
Cumulative Sum	2.19E+10	2.53E+10	7.14E+10	7.37E+10	8.25E+10	8.22E+10	9.90E+10	3.68E+10	4.90E+10

Relative % Error	-1.03%	-2.36%	-1.30%	-1.24%	-1.58%	-1.60%	-1.72%	-0.72%	-0.60%
------------------	--------	--------	--------	--------	--------	--------	--------	--------	--------

Subwatershed Percent Reductions

Source Category	CR 650 W	CR 825 W	CR 925 W	SR 132/13	CR 1000 W	Cyntheanne Rd	70-0026	Wm Lock E206th/ Durbin Rd	Wm Lock Ditch @ E196th
Manure Application	75%	89%	99%	93%	92%	92%	86%	95%	87%
Active CAFOs	-----	-----	60%	-----	-----	-----	-----	60%	-----
Domestic Animals	60%	70%	99%	90%	91%	70%	80%	95%	70%
NPDES	-----	-----	-----	0%	0%	-----	0%	-----	-----
Non-CAFO Livestock	75%	89%	99%	93%	92%	92%	86%	95%	87%
Failing Septic CSOs	60%	70%	99%	91%	91%	75%	80%	95%	70%
Wildlife	60%	70%	99%	90%	91%	70%	80%	95%	70%

Table C-15 (continued) .Stony Creek *E. coli* Load Allocations and Source Category Percent Reductions

Source Category	E 196th St	Wm Lehr Ditch @ 166th	Wm Lehr @ Private Dr /SR 38	SR 38	Union Chapel Rd	Cumberland Rd Gage	North Trib @ 166th Noblesville	Allisonville Rd.
Required % Reduction	89.85%	89.75%	90.86%	91.65%	93.31%	81.24%	77.01%	75.65%
Target Median Load	4.22E+10	9.50E+10	1.00E+11	7.26E+09	1.31E+10	5.36E+10	2.48E+10	2.30E+10

Median Daily Load Allocations (colonies /day)

Source Category	E 196th St	Wm Lehr Ditch @ 166th	Wm Lehr @ Private Dr /SR 38	SR 38	Union Chapel Rd	Cumberland Rd Gage	North Trib @ 166th Noblesville	Allisonville Rd.
Manure Application	3.01E+10	5.768E+10	5.75E+10	2.70E+09	7.28E+09	2.10E+10	9.59E+09	6.68E+09
Active CAFOs	-----	-----	-----	-----	-----	-----	-----	-----
Domestic Animals	9.50E+08	2.36E+09	1.00E+10	1.14E+09	1.31E+09	6.36E+08	4.02E+09	3.77E+09
NPDES	-----	-----	-----	-----	-----	-----	2.66E+05	-----
Non-CAFO Livestock	2.01E+09	4.151E+09	5.54E+09	4.68E+08	6.39E+08	1.91E+09	5.26E+08	7.30E+08
Failing Septic	3.61E+09	1.542E+10	8.58E+09	1.92E+09	1.96E+09	2.64E+10	2.37E+09	9.06E+09
CSOs	-----	-----	-----	-----	-----	-----	6.73E+09	-----
Wildlife	5.24E+09	1.309E+10	1.74E+10	9.83E+08	1.65E+09	3.33E+09	1.27E+09	2.15E+09
Upstream Load	2.06E+10	0	1.11E+10	3.66E+10	2.79E+09	1.47E+09	0	1.28E+10
Subwatershed Sum	4.19E+10	9.27E+10	9.90E+10	7.22E+09	1.29E+10	5.34E+10	2.45E+10	2.24E+10
Cumulative Sum	6.26E+10	9.27E+10	1.10E+11	4.38E+10	1.56E+10	5.48E+10	2.45E+10	3.52E+10

Relative % Error	-0.56%	-2.46%	-1.11%	-0.47%	-2.14%	-0.38%	-1.26%	-2.60%
------------------	--------	--------	--------	--------	--------	--------	--------	--------

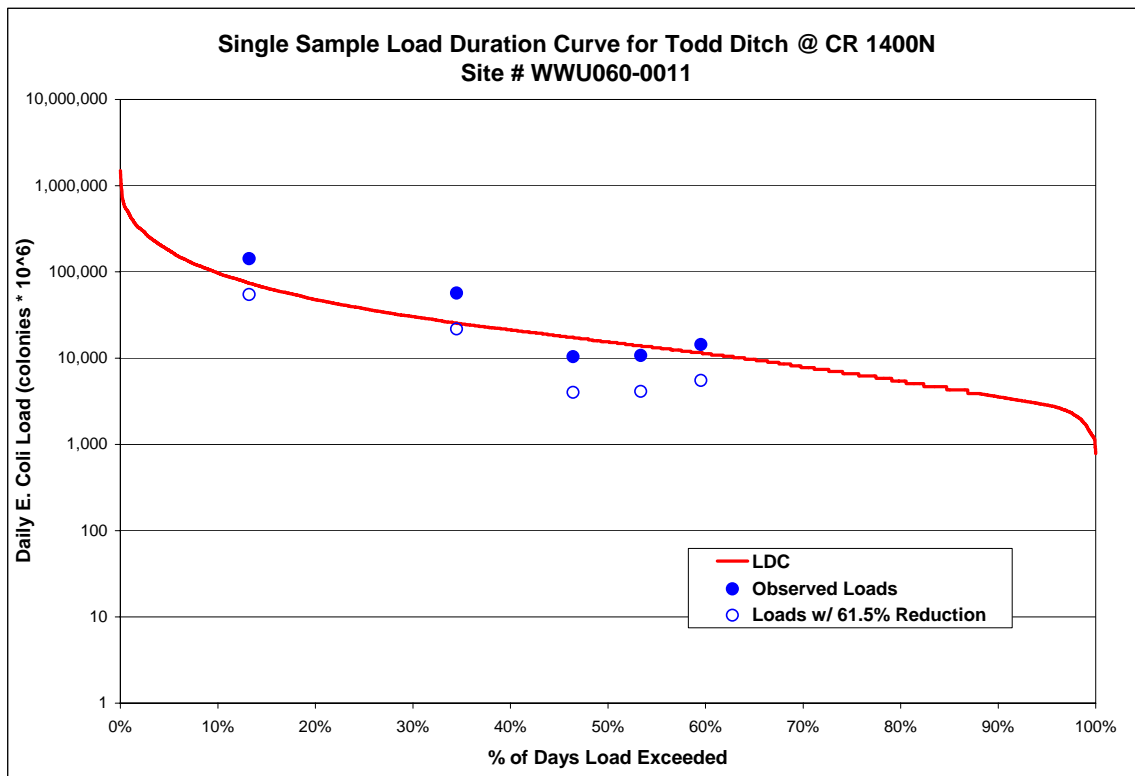
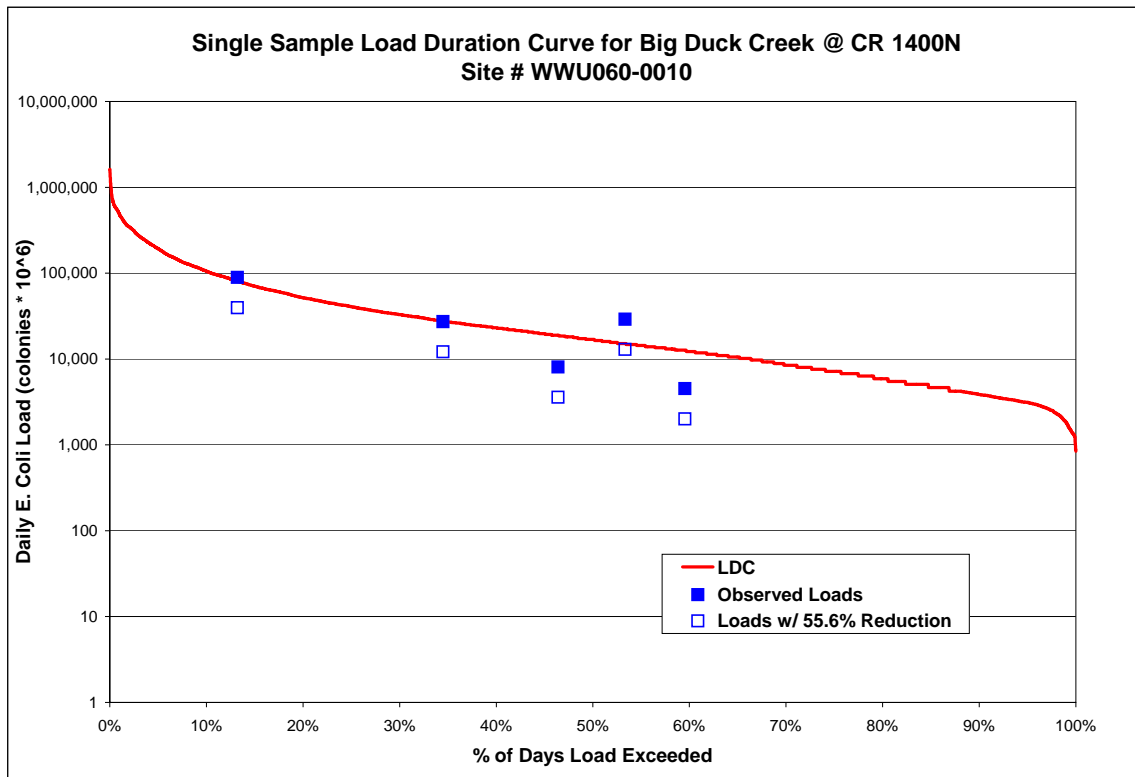
Subwatershed Percent Reductions

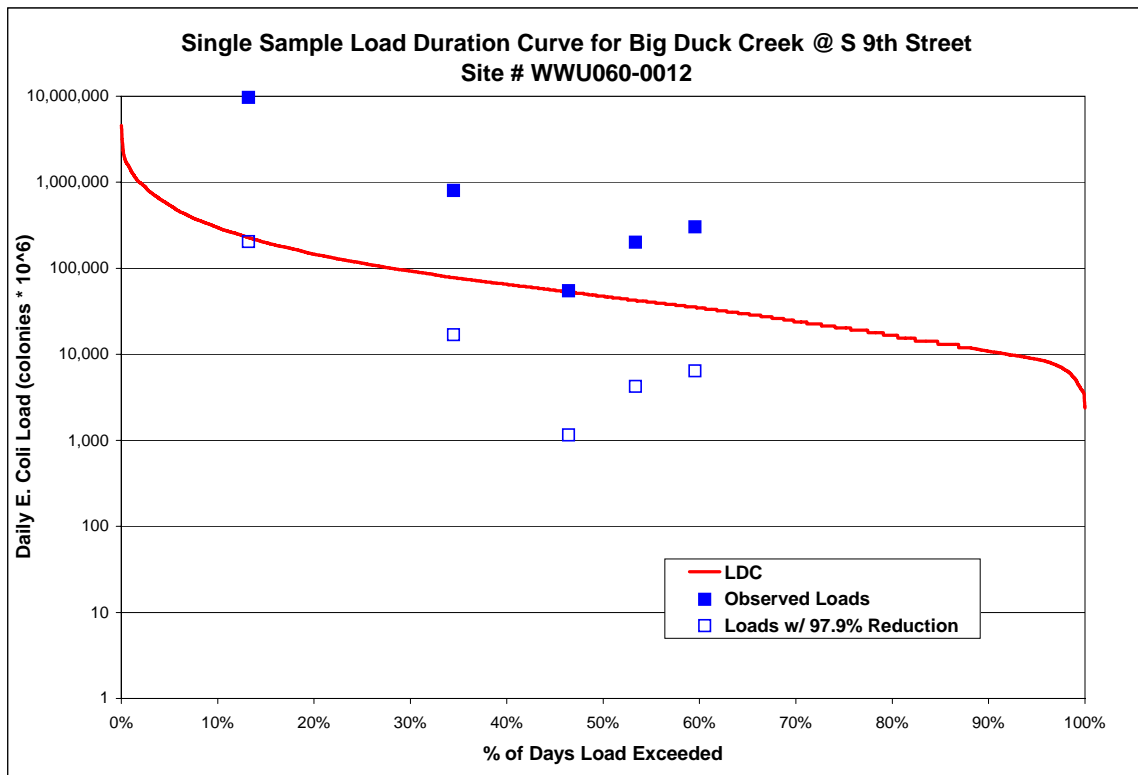
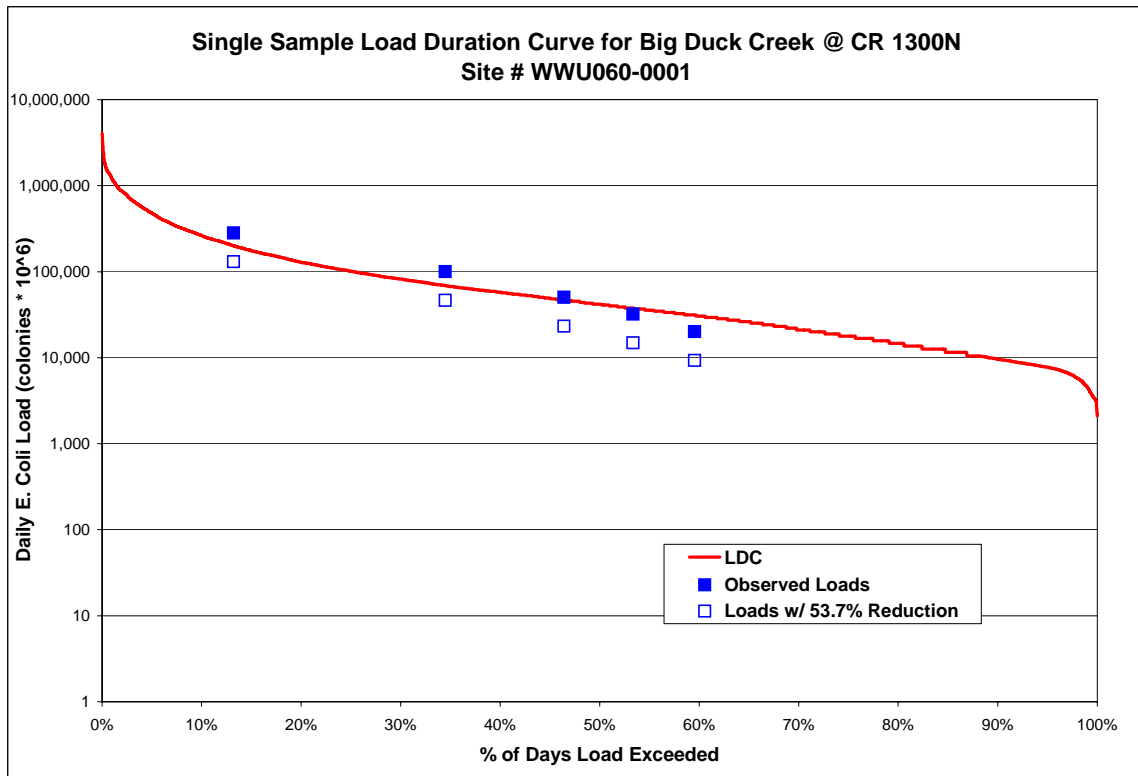
Source Category	E 196th St	Wm Lehr Ditch @ 166th	Wm Lehr @ Private Dr /SR 38	SR 38	Union Chapel Rd	Cumberland Rd Gage	North Trib @ 166th Noblesville	Allisonville Rd.
Manure Application	91%	92%	93%	95%	95%	86%	82%	85%
Active CAFOs	-----	-----	-----	-----	-----	-----	-----	-----
Domestic Animals	82%	80%	80%	80%	87%	75%	80%	60%
NPDES	-----	-----	-----	-----	-----	-----	0%	-----
Non-CAFO Livestock	91%	92%	93%	95%	95%	86%	82%	85%
Failing Septic	85%	80%	85%	85%	87%	75%	80%	70%
CSOs	-----	-----	-----	-----	-----	-----	50%	-----
Wildlife	82%	80%	80%	80%	87%	75%	80%	60%

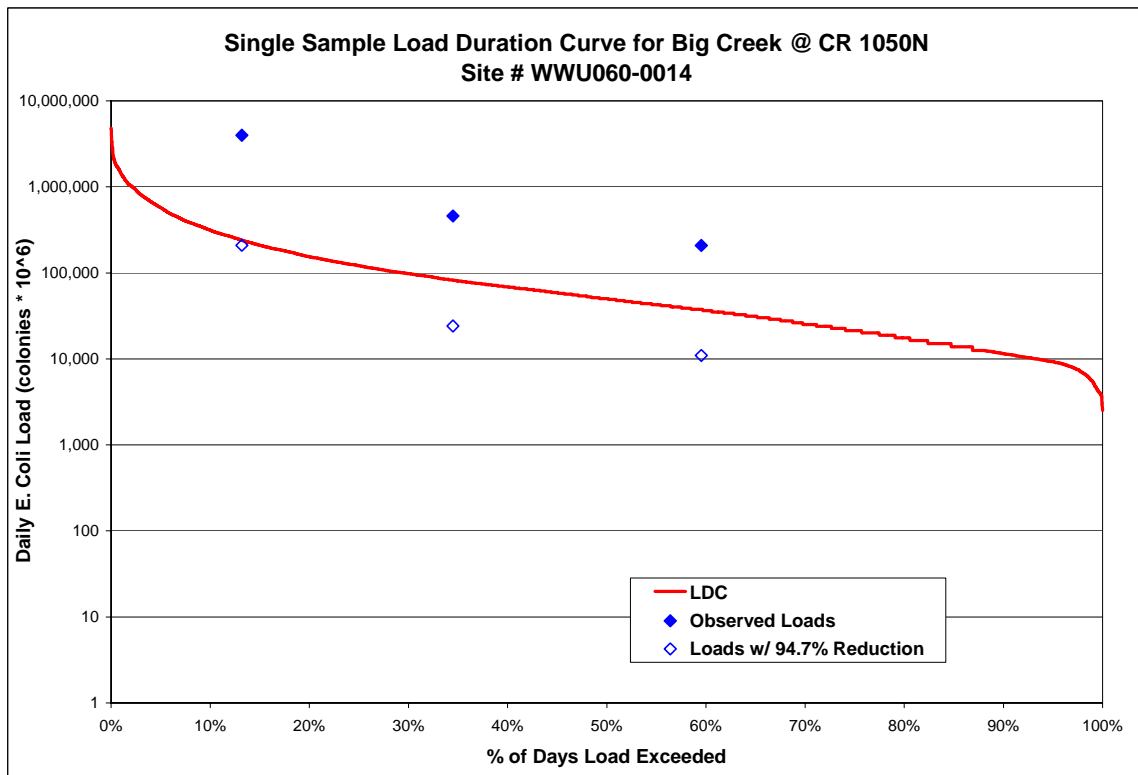
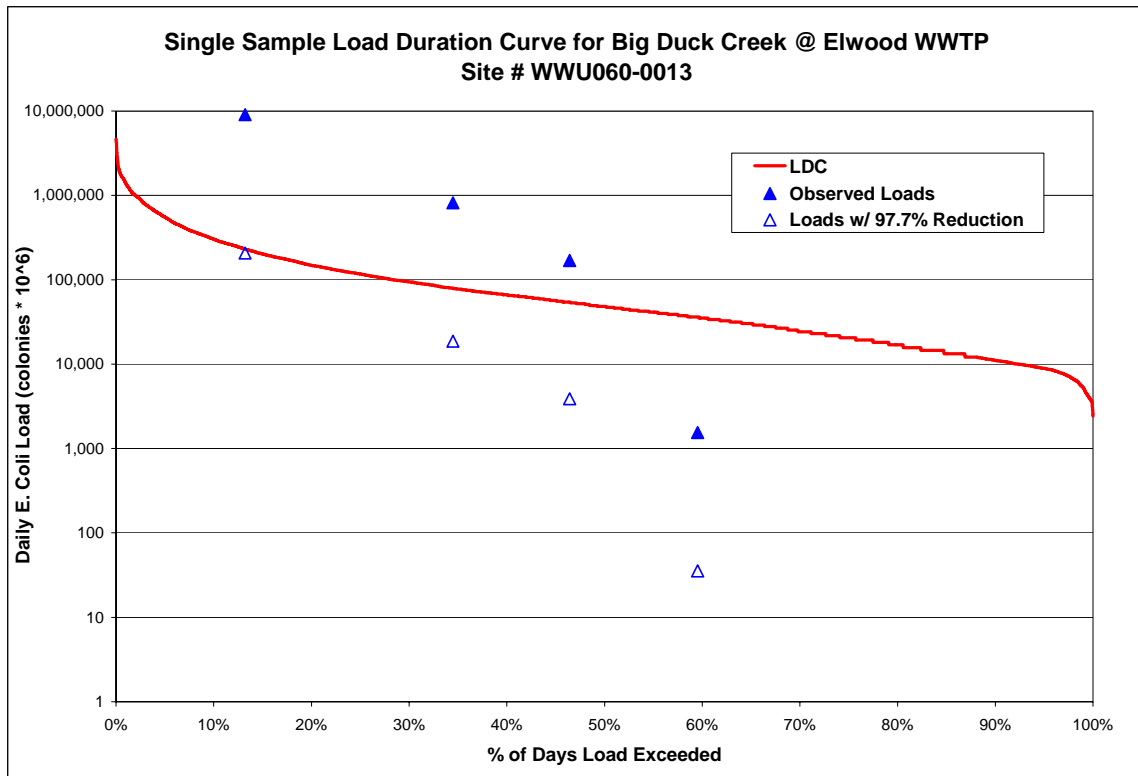
APPENDIX D

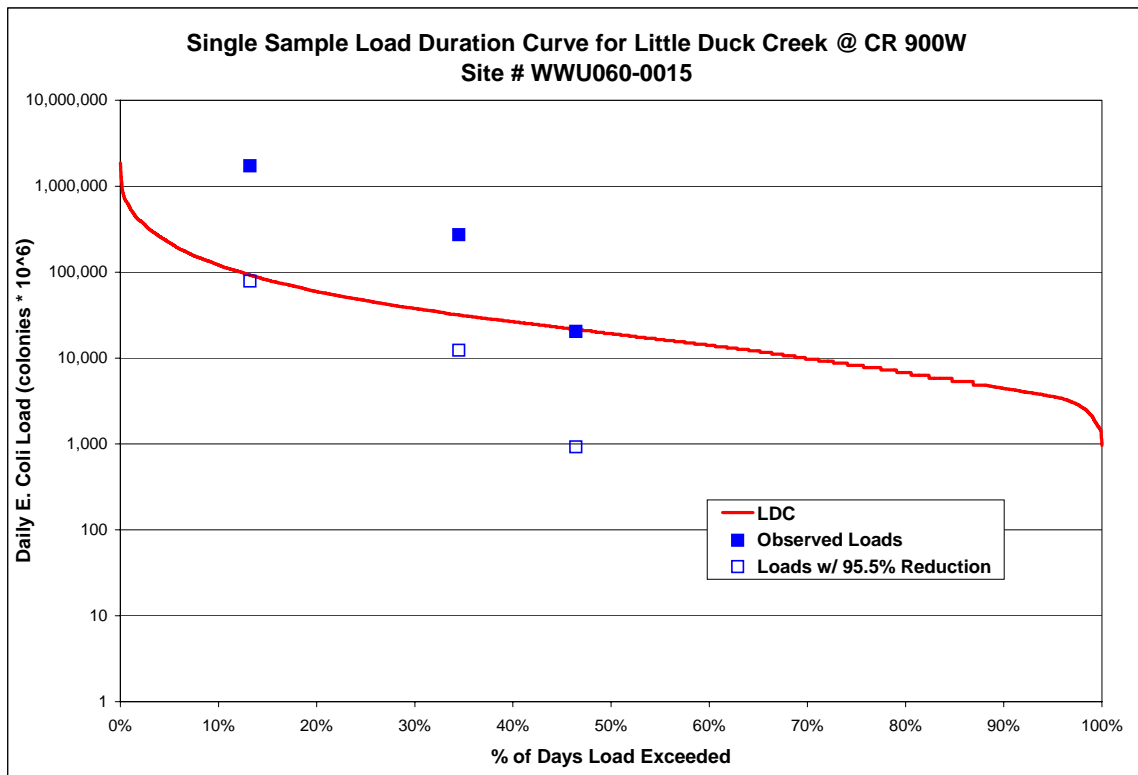
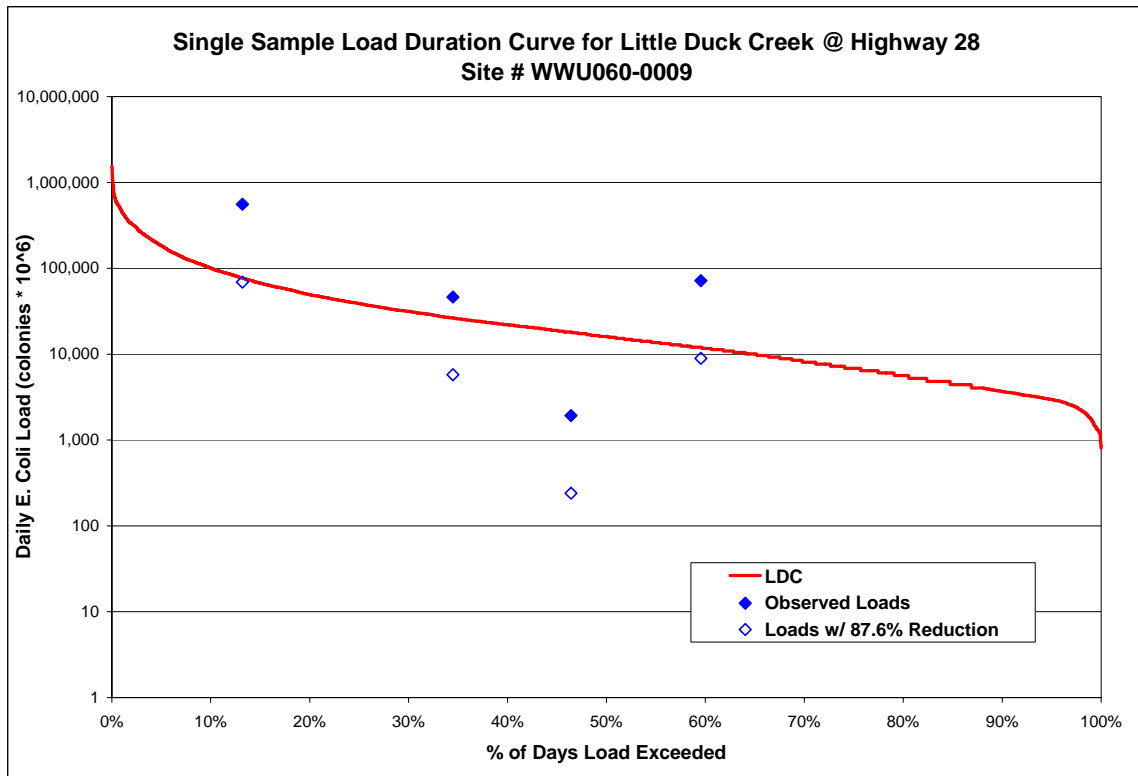
SINGLE SAMPLE LOAD DURATION CURVES

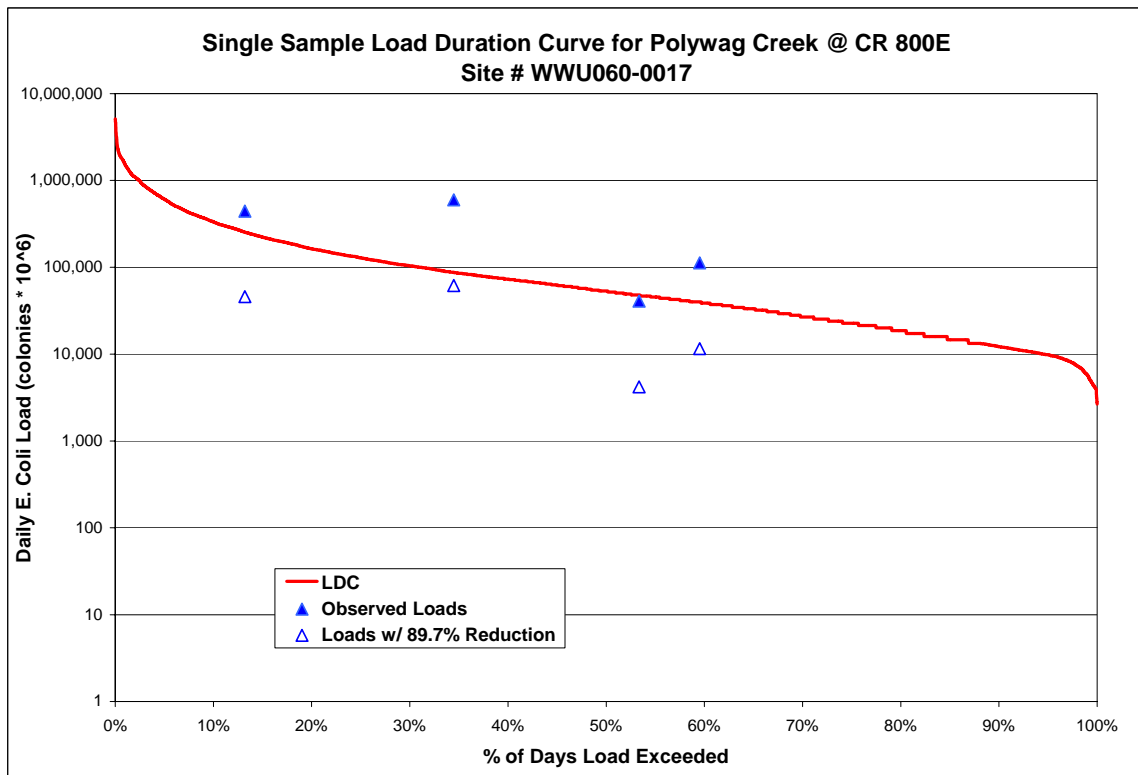
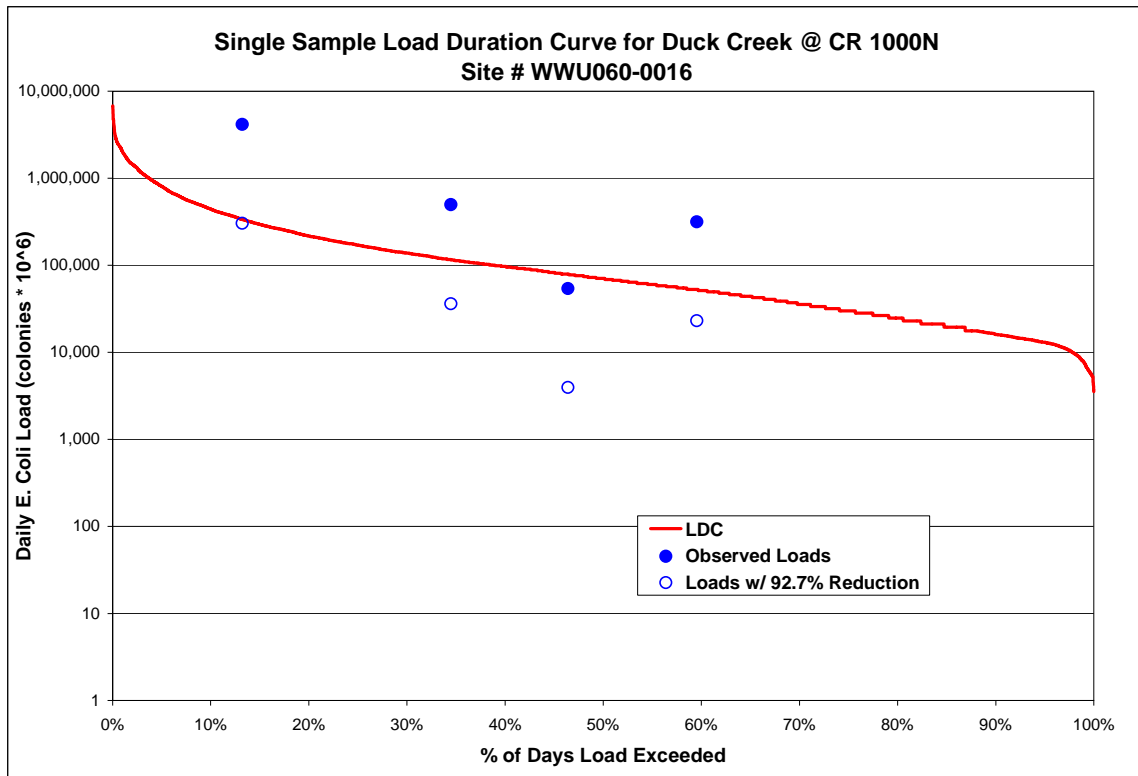
Single Sample Load Duration Curves for Duck Creek Watershed

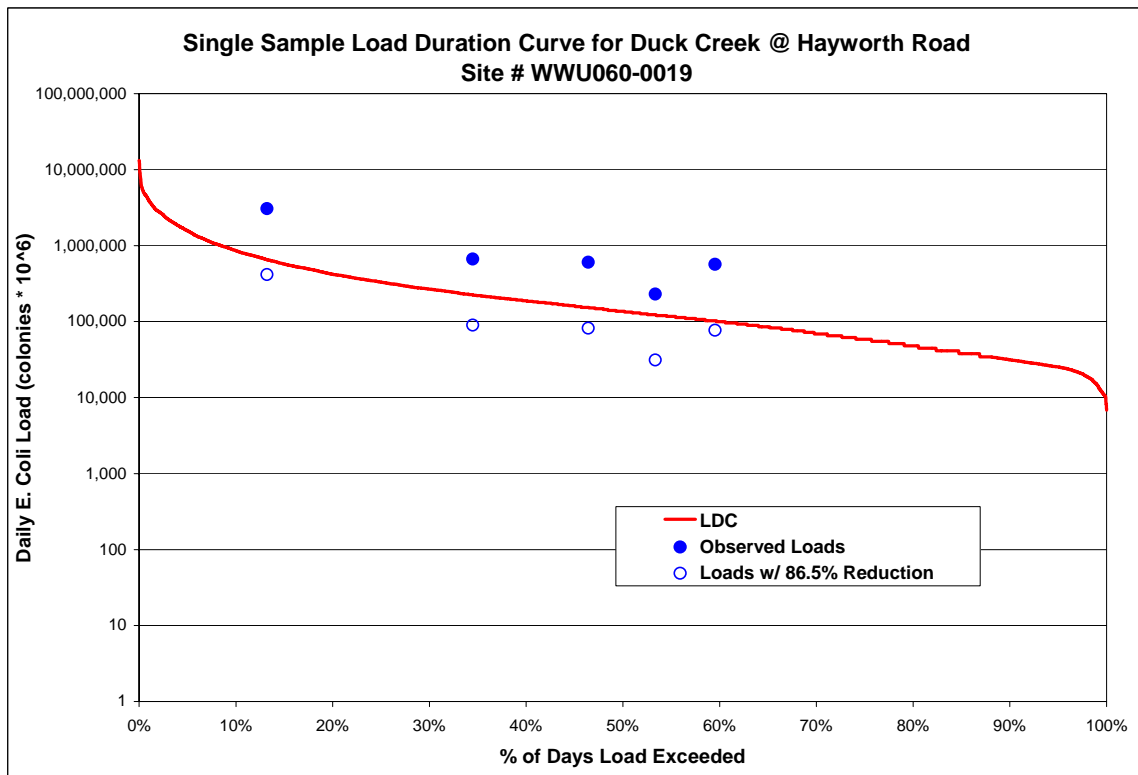
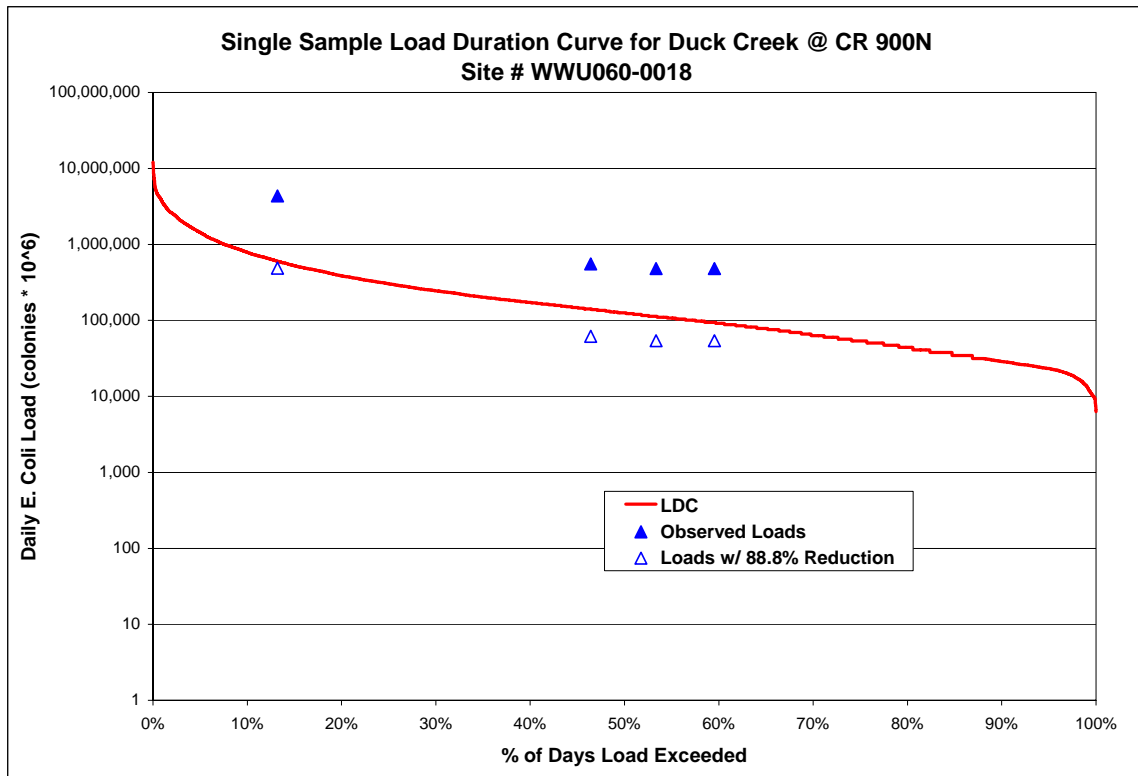


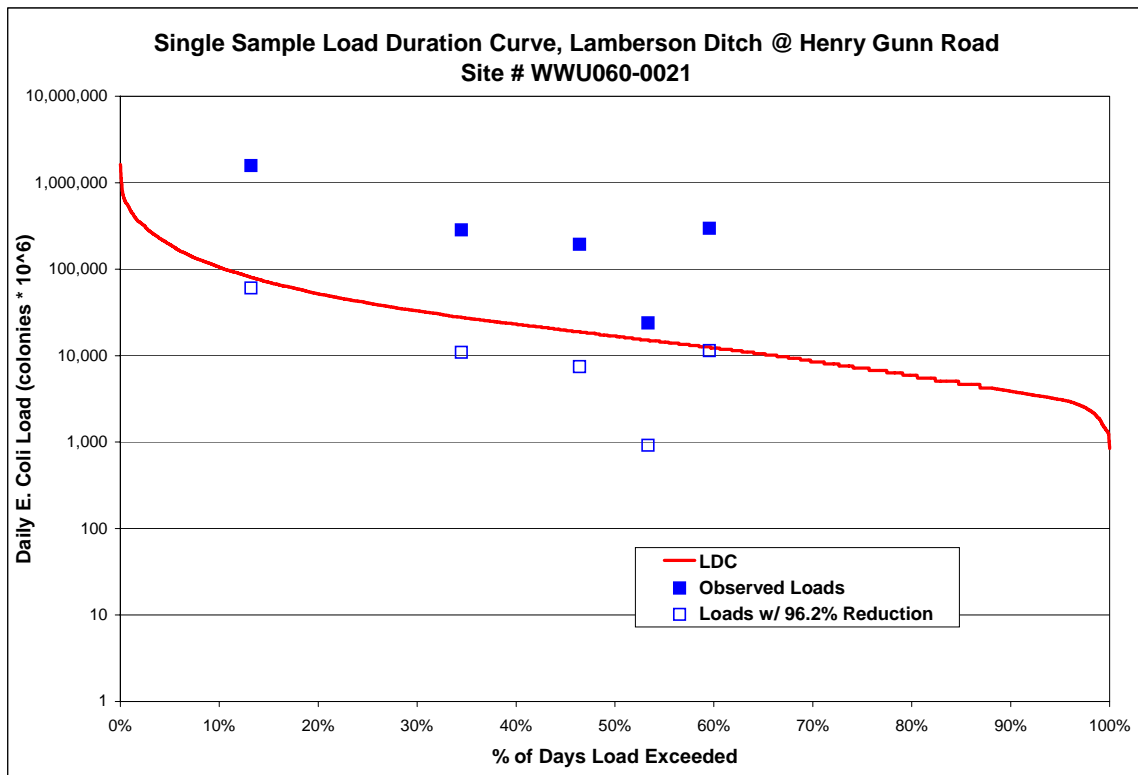
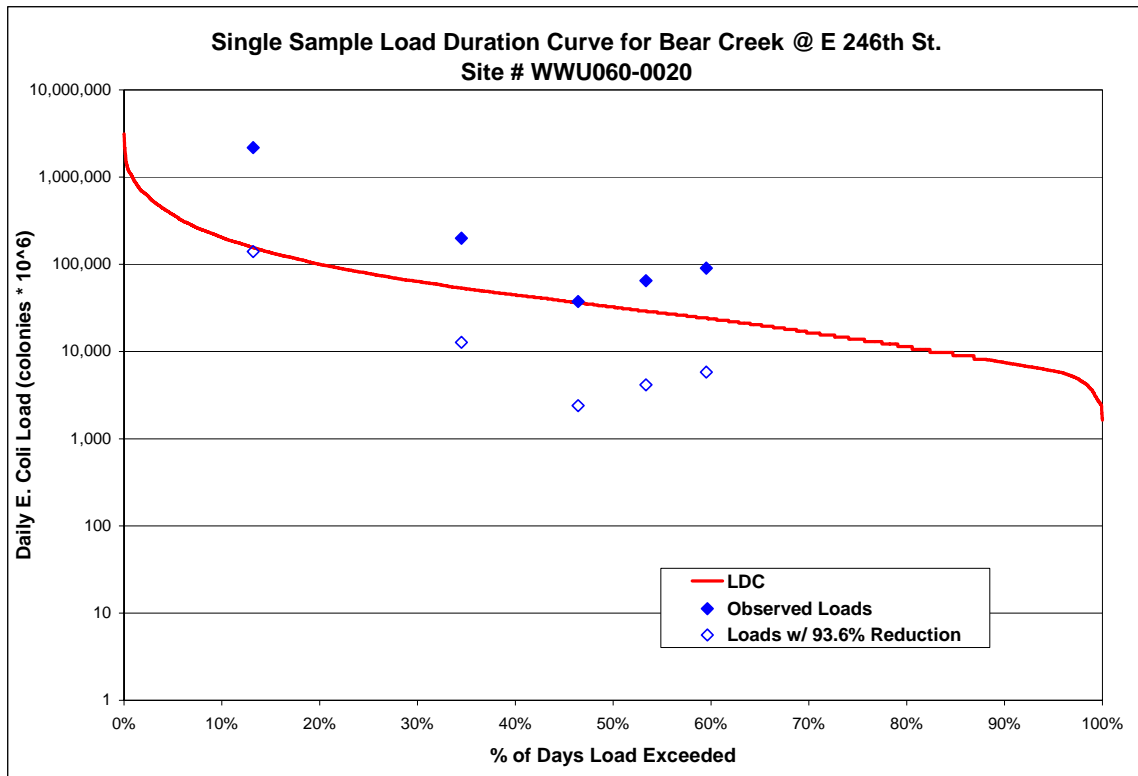


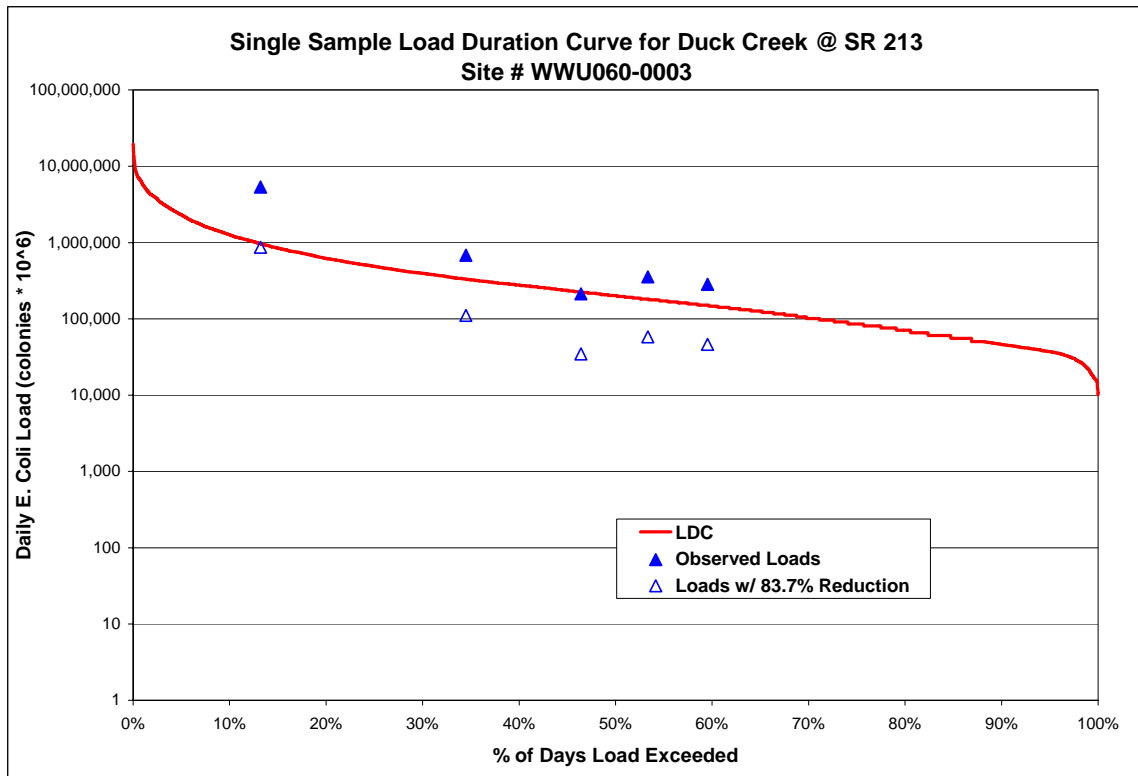




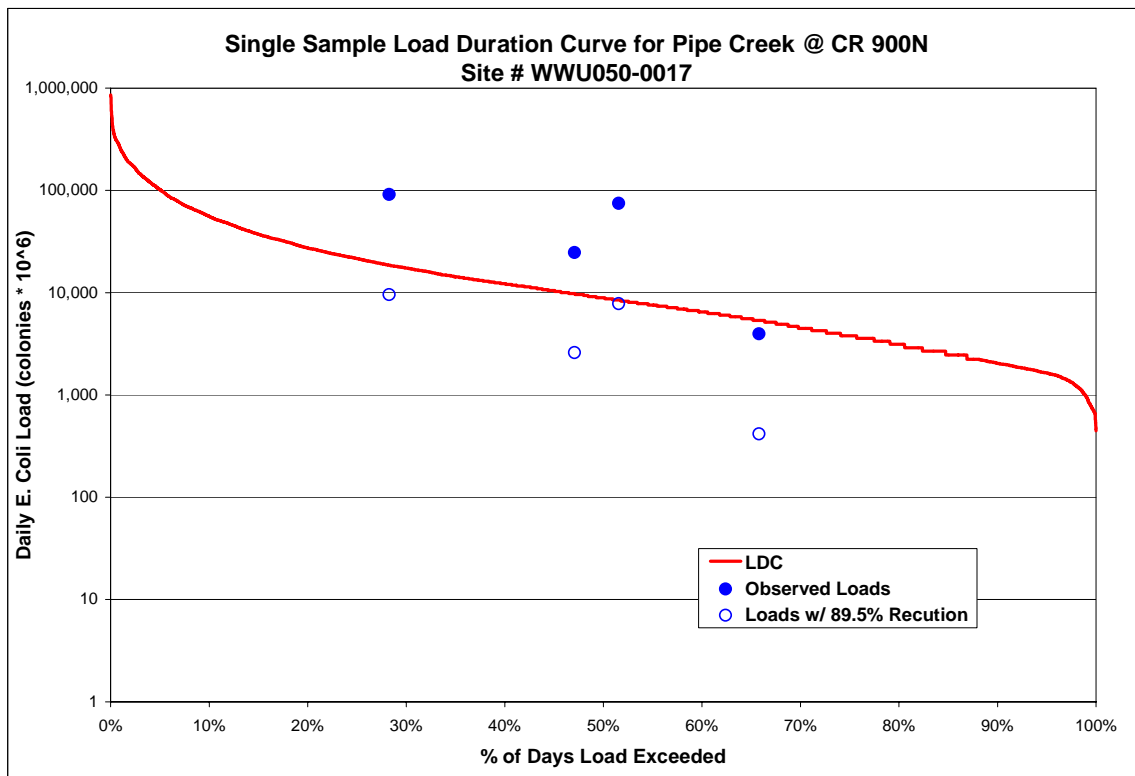
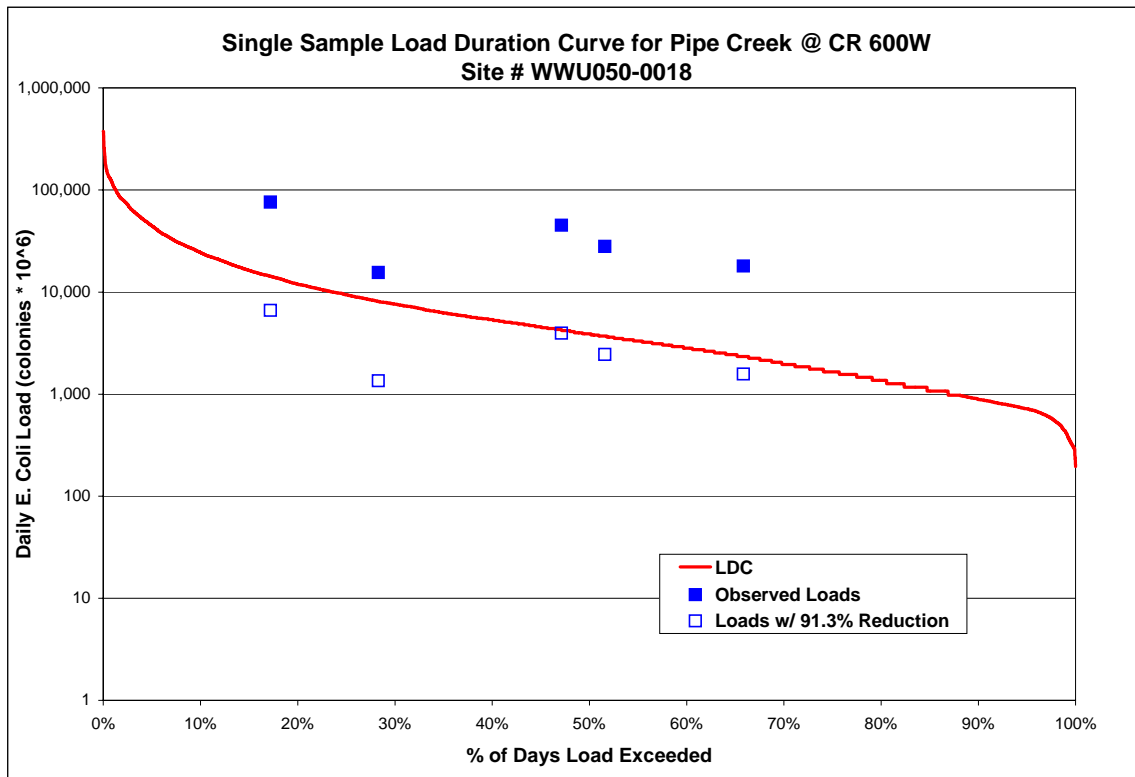


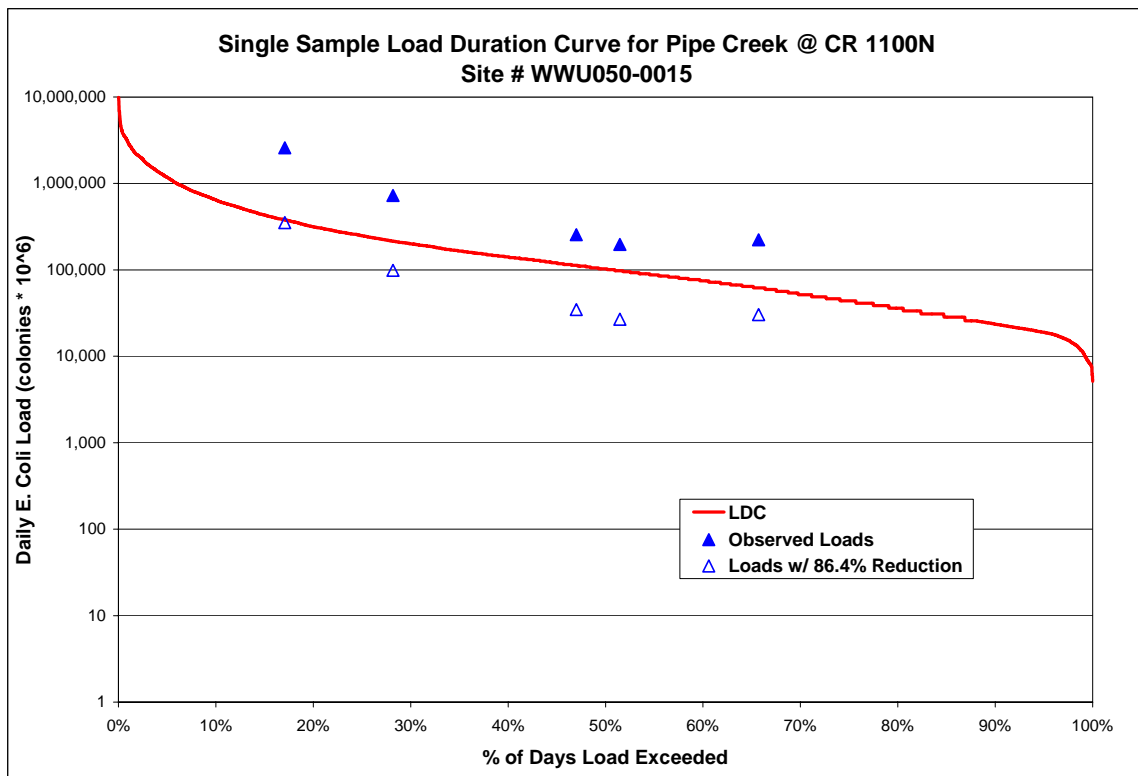
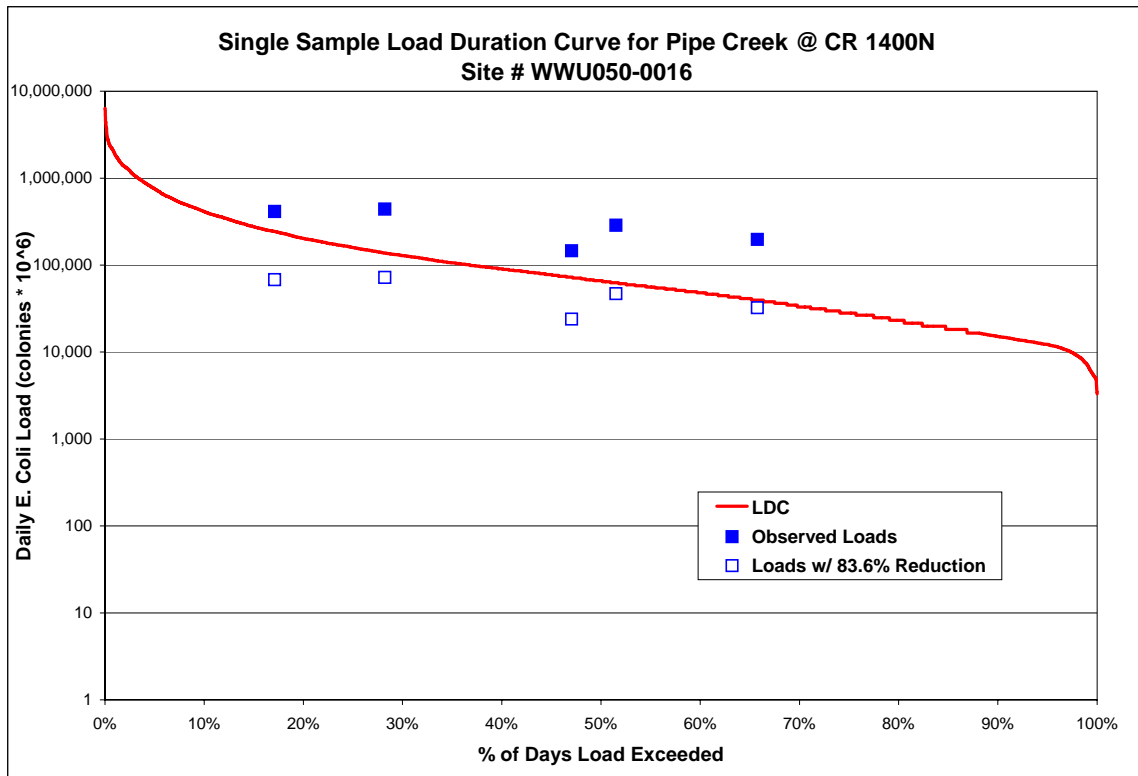


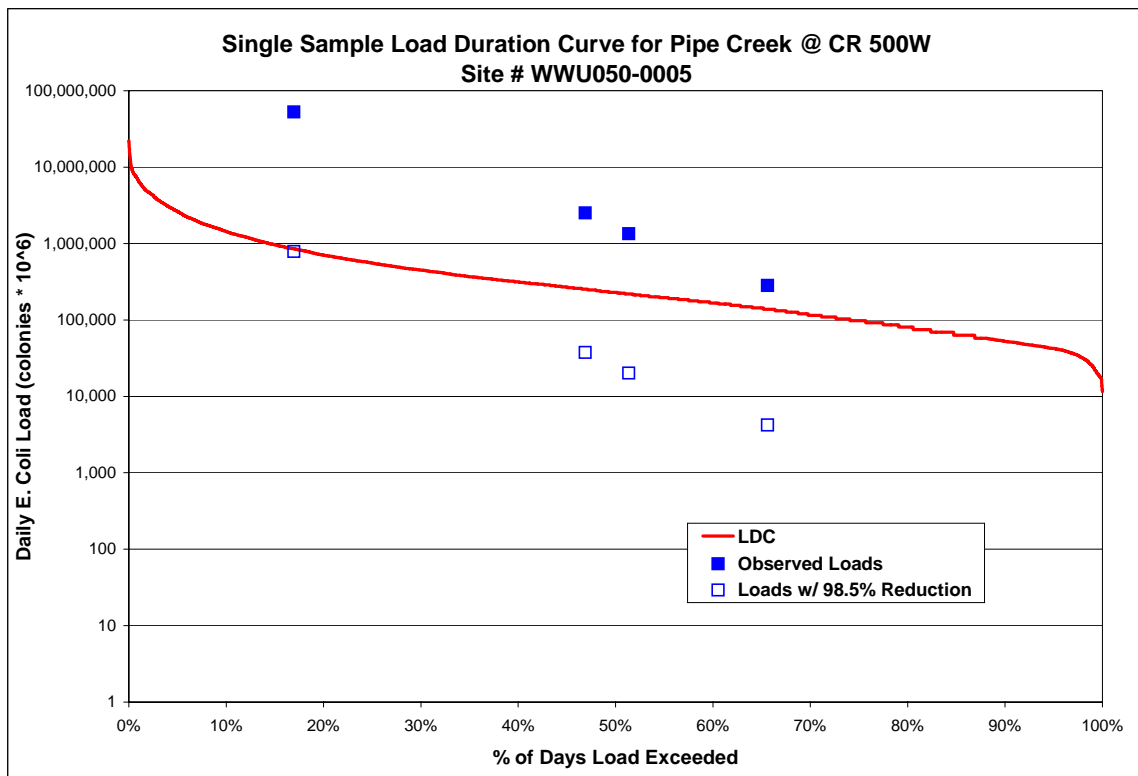
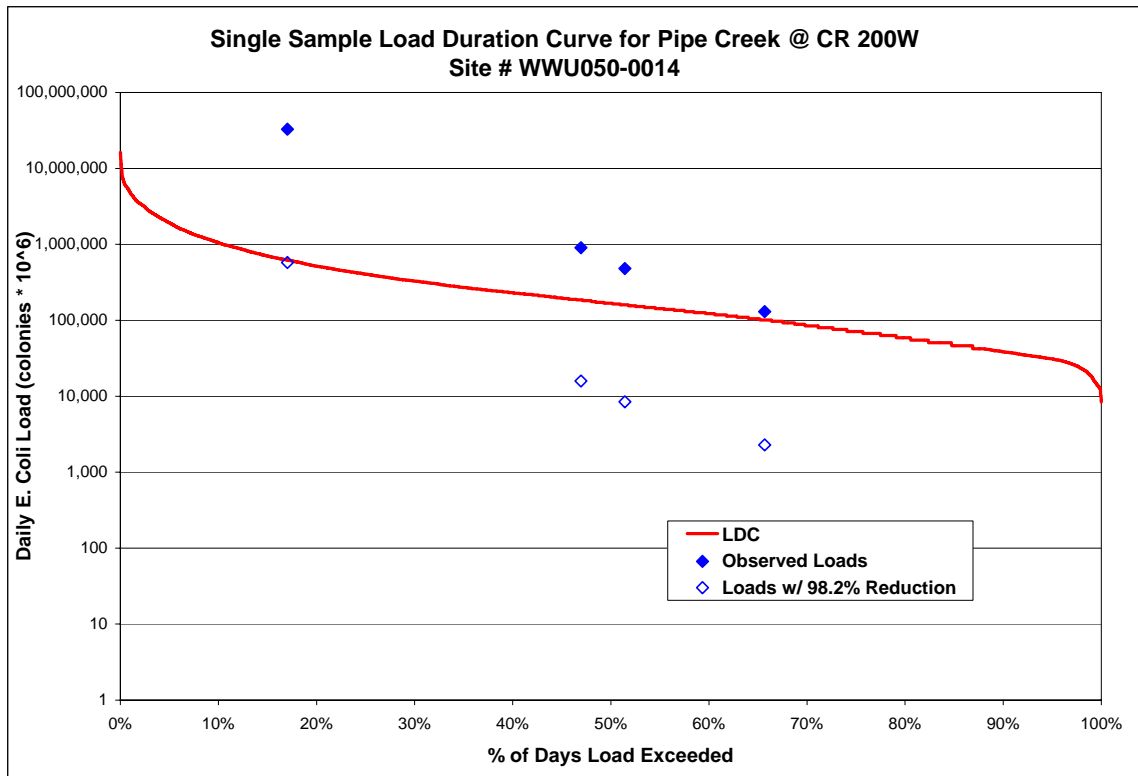


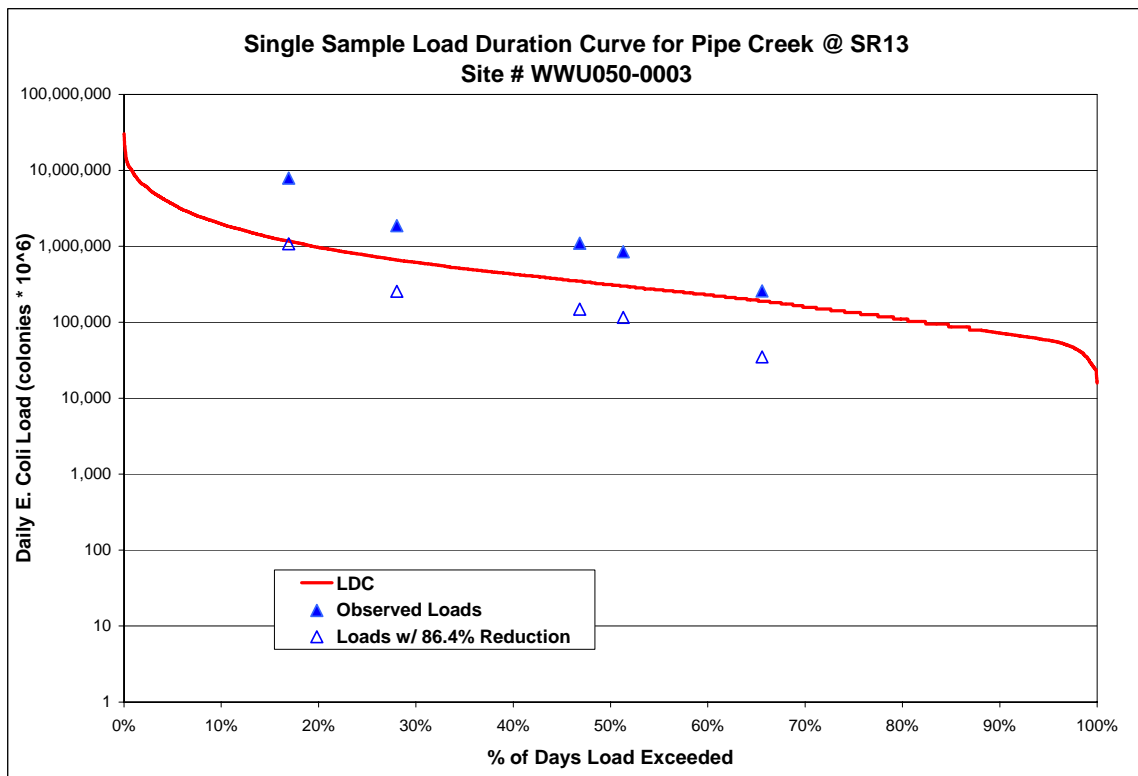
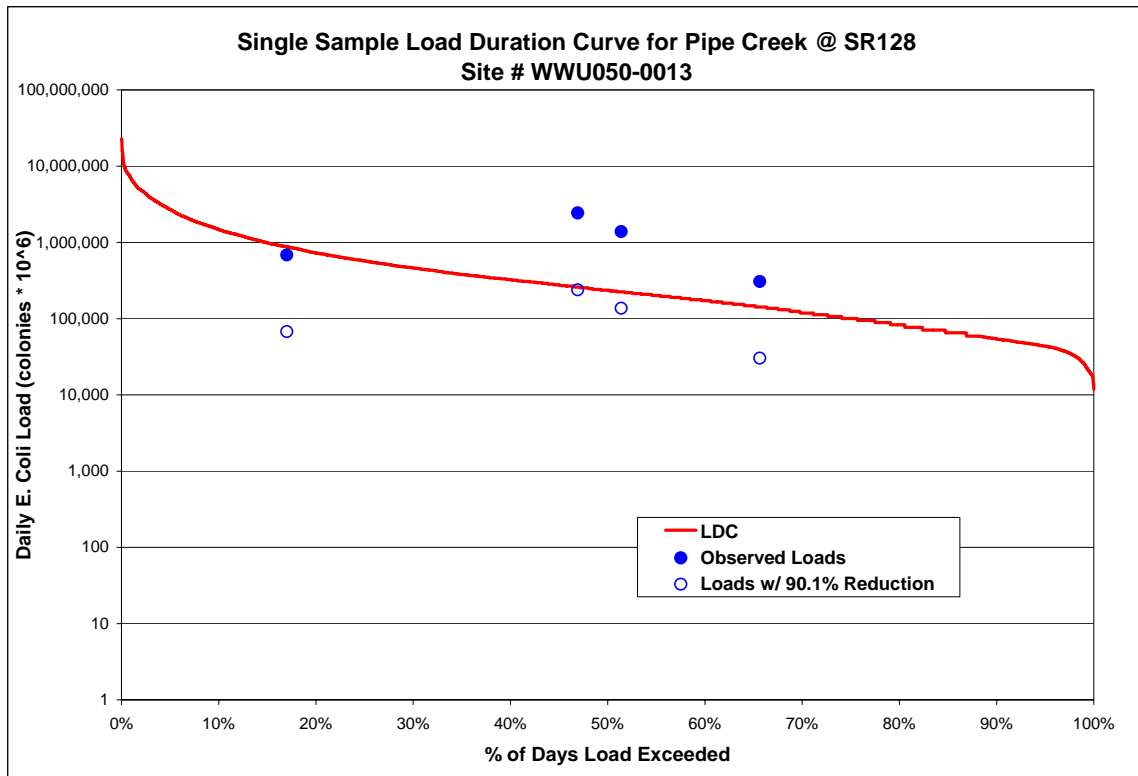


Single Sample Load Duration Curves for Pipe Creek Watershed

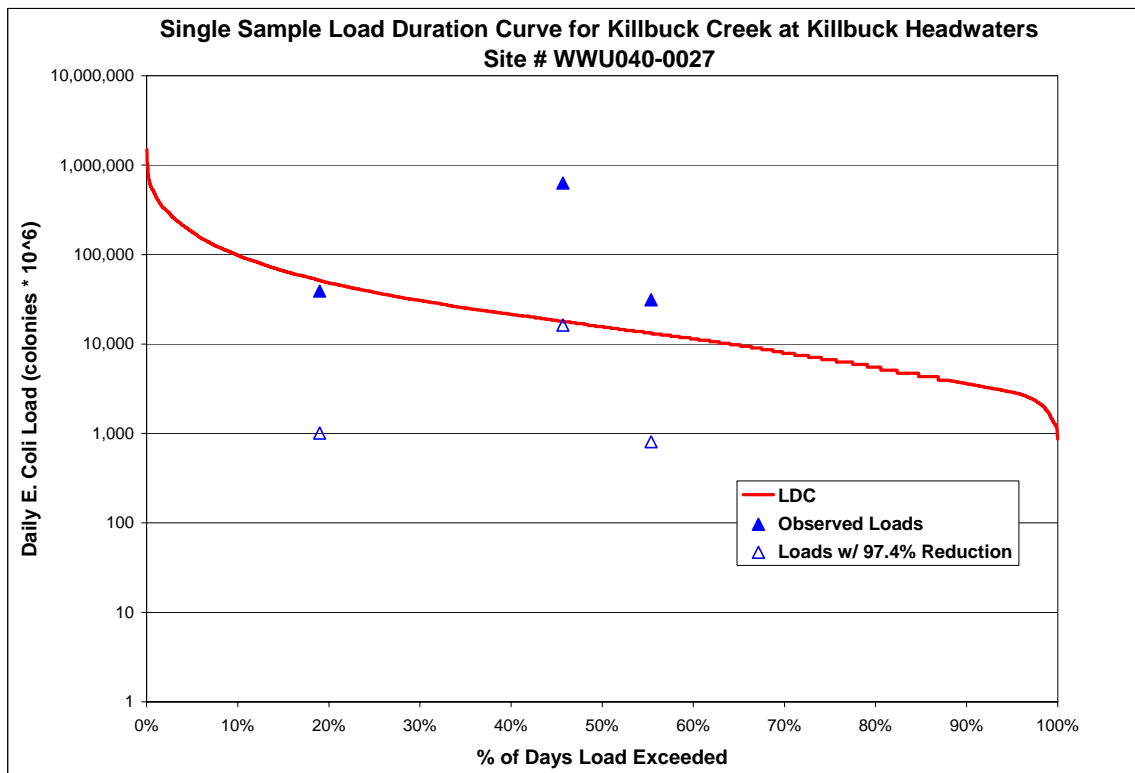
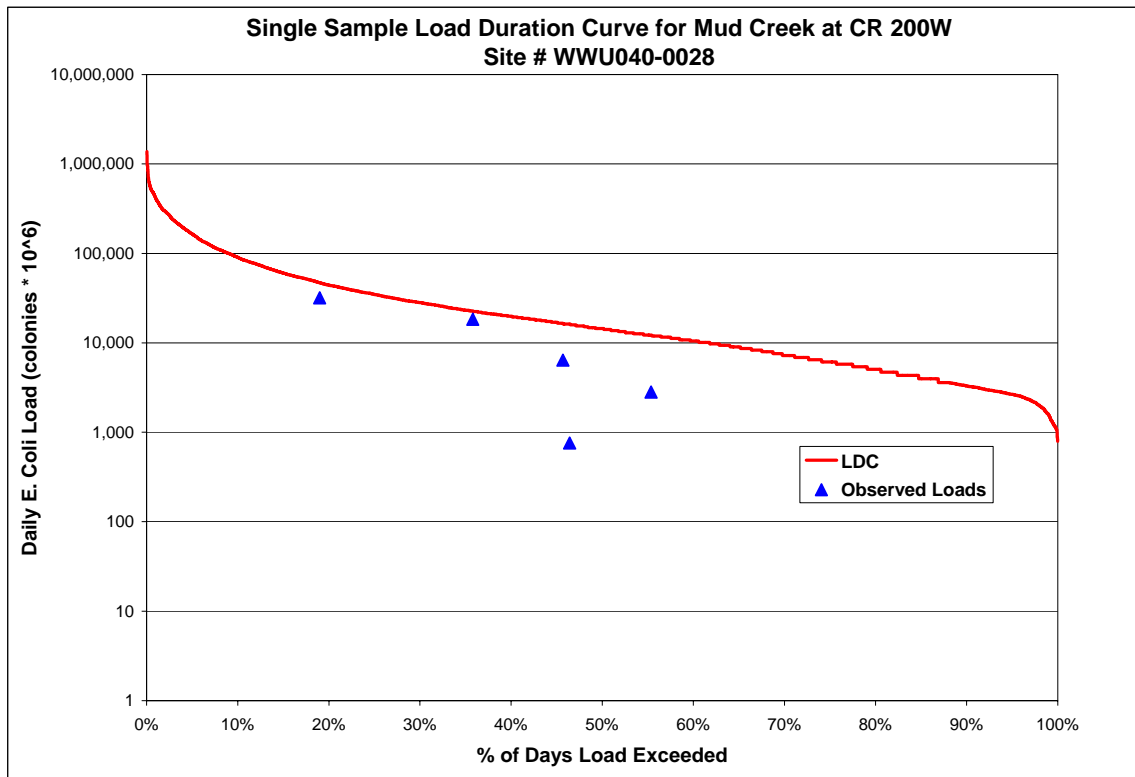


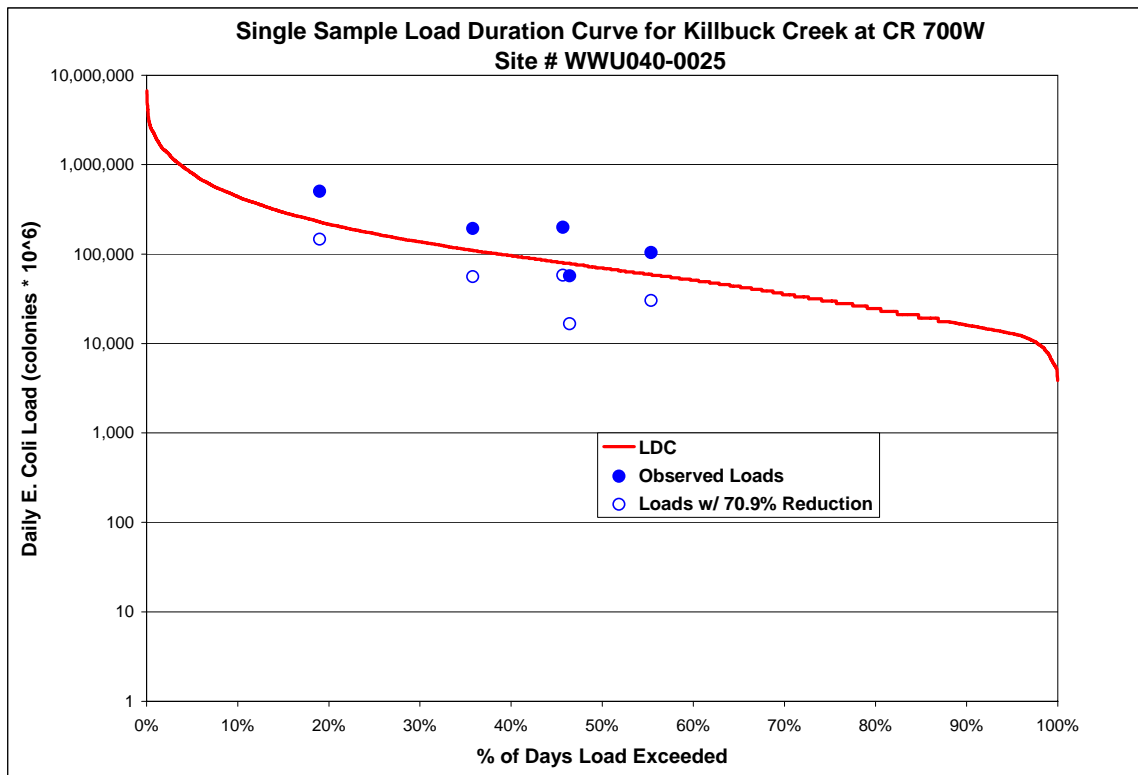
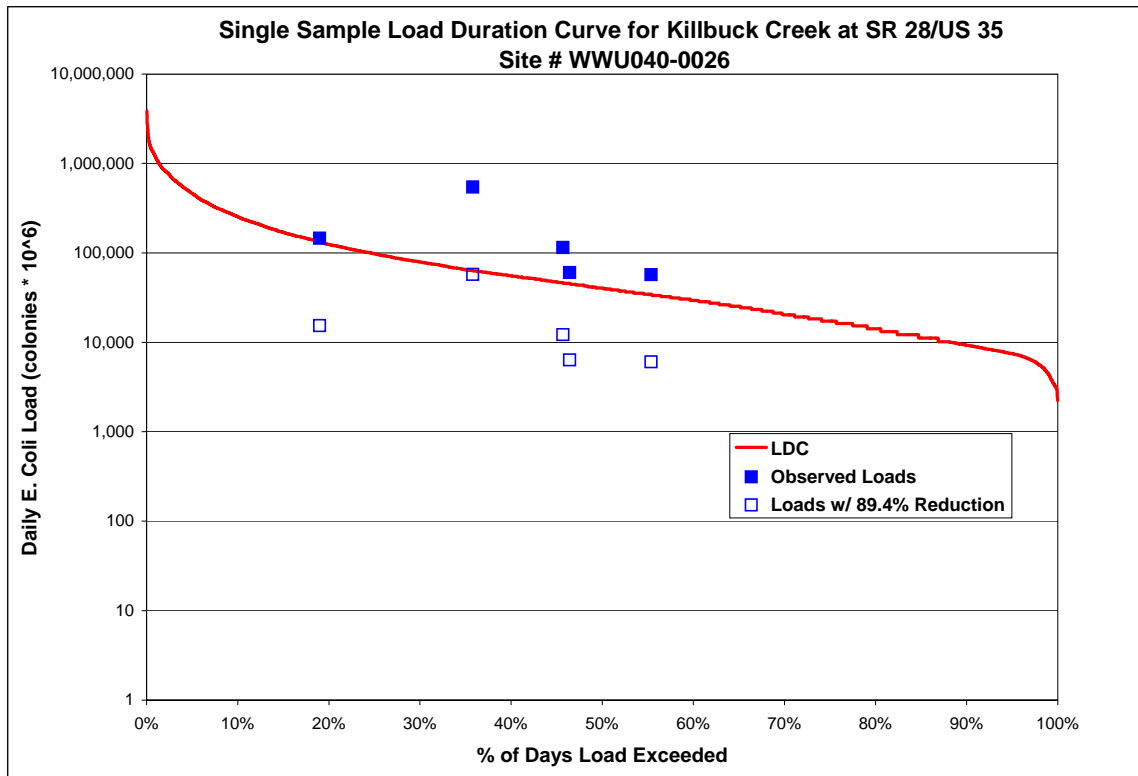


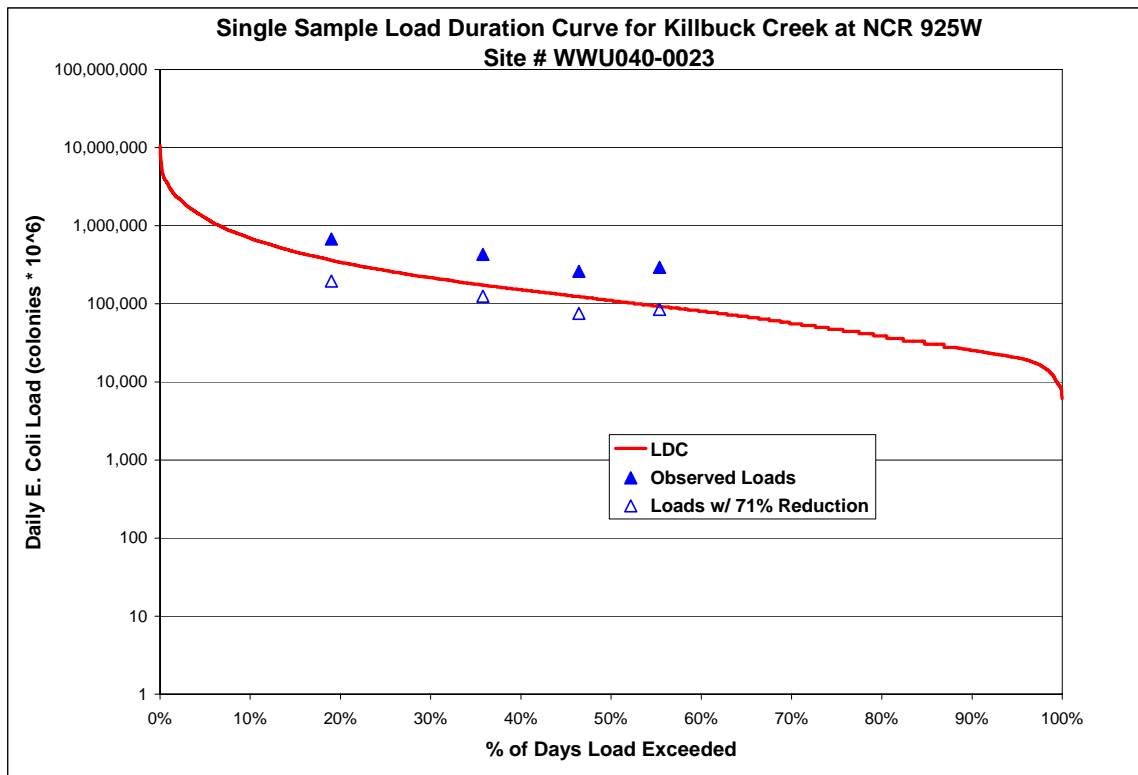
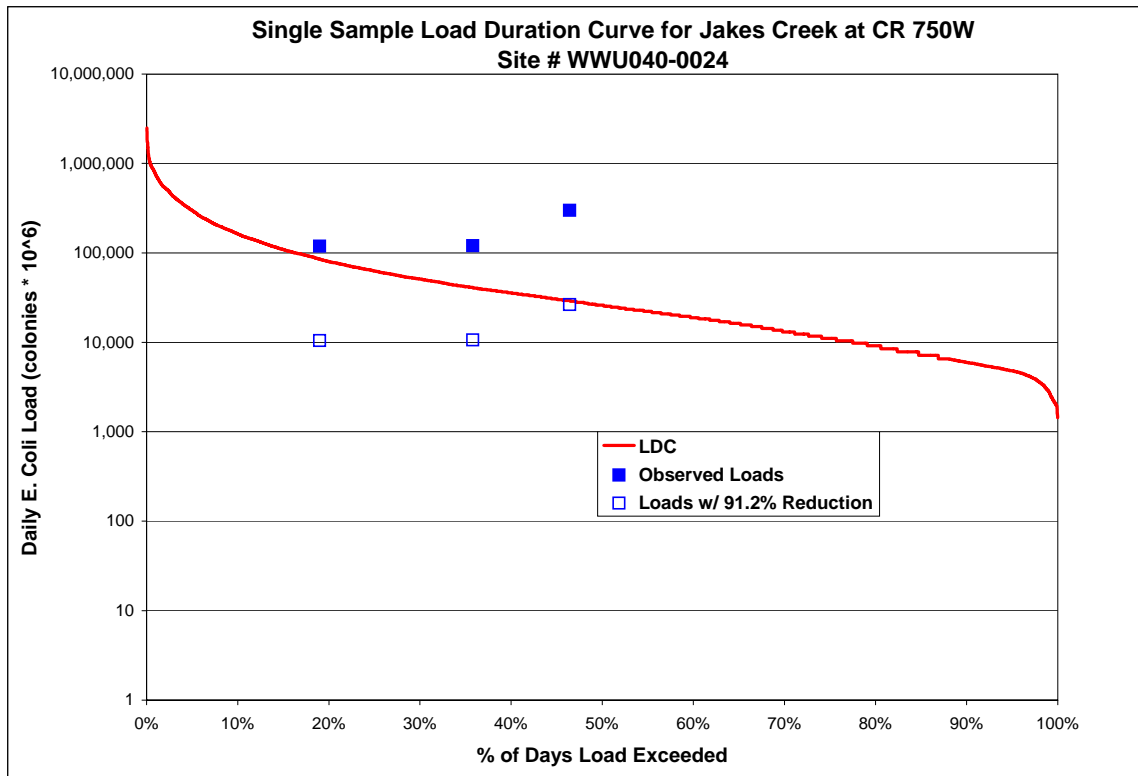


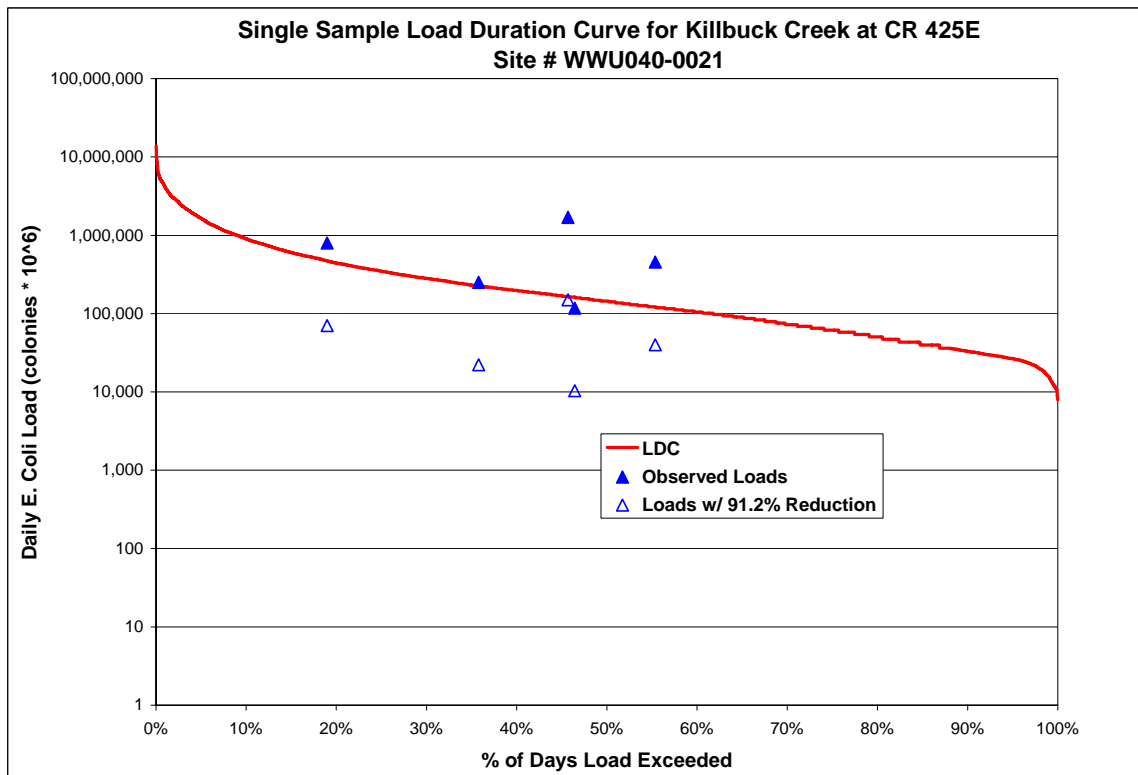
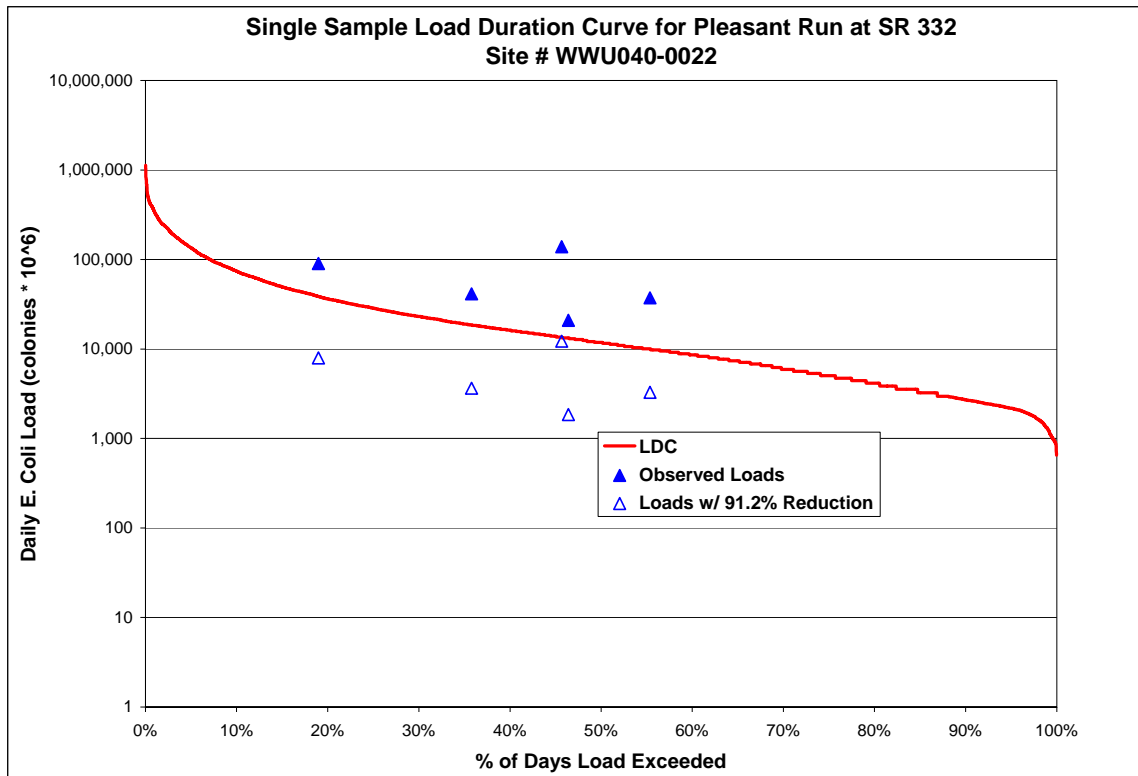


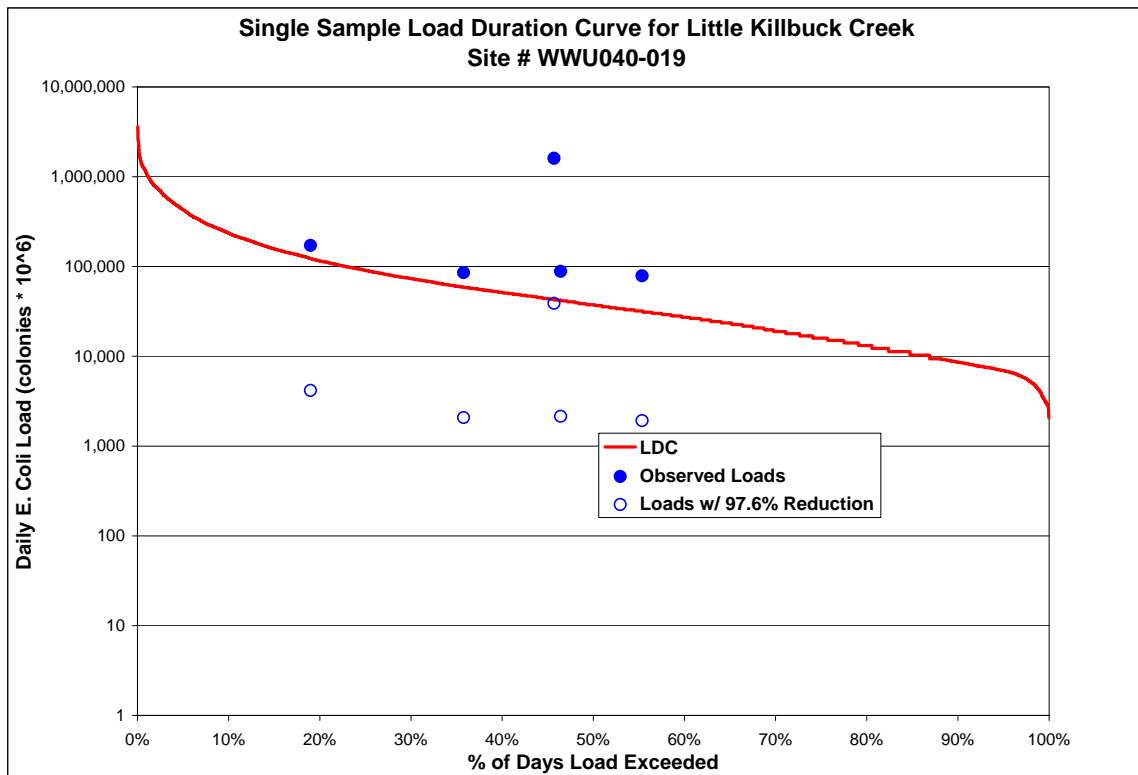
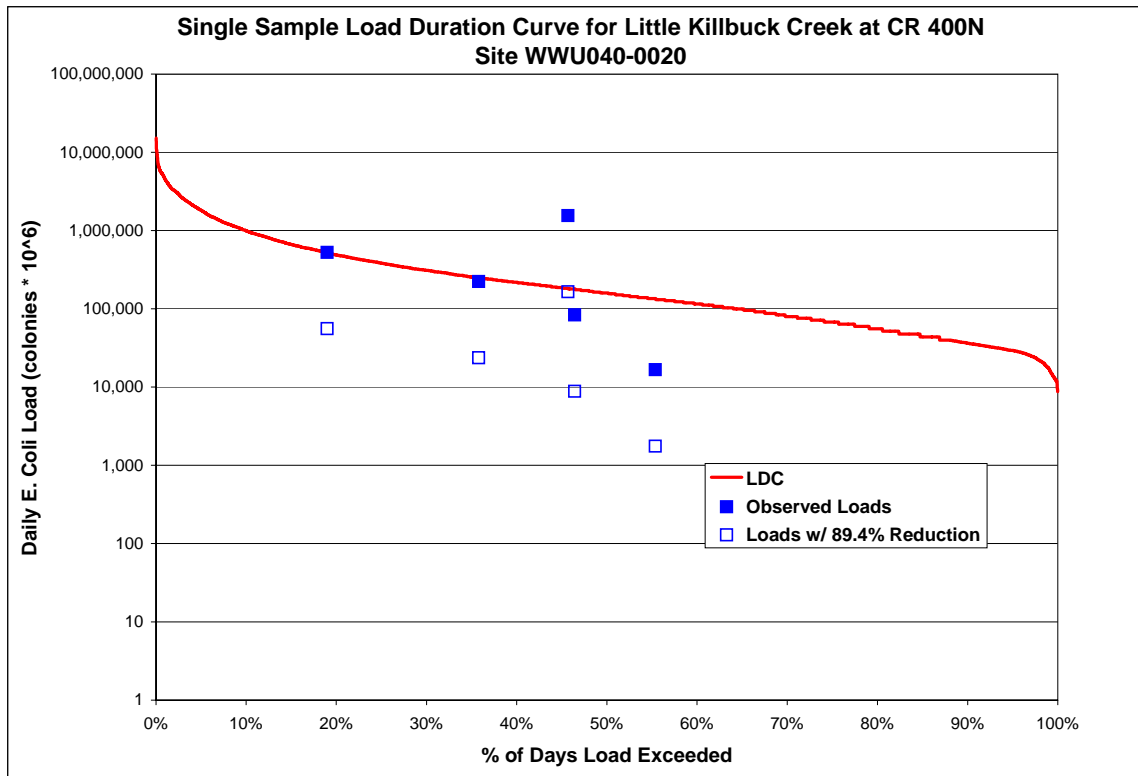
Single Sample Load Duration Curves for Killbuck Creek Watershed

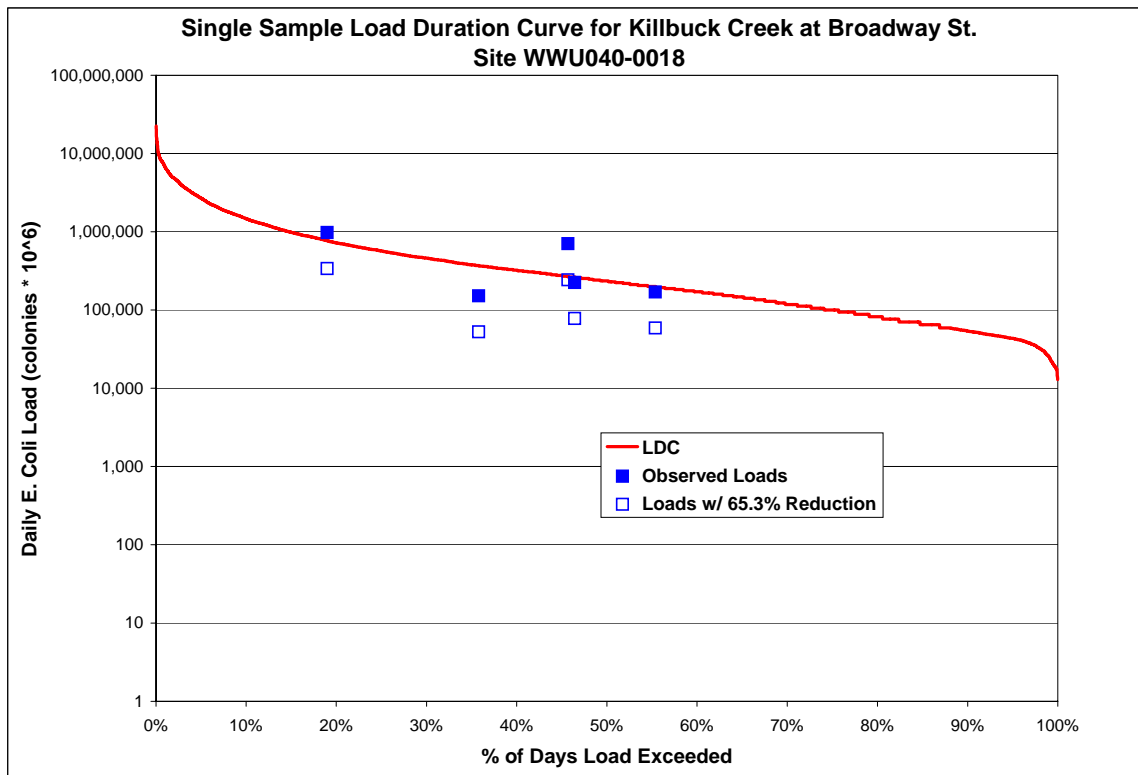
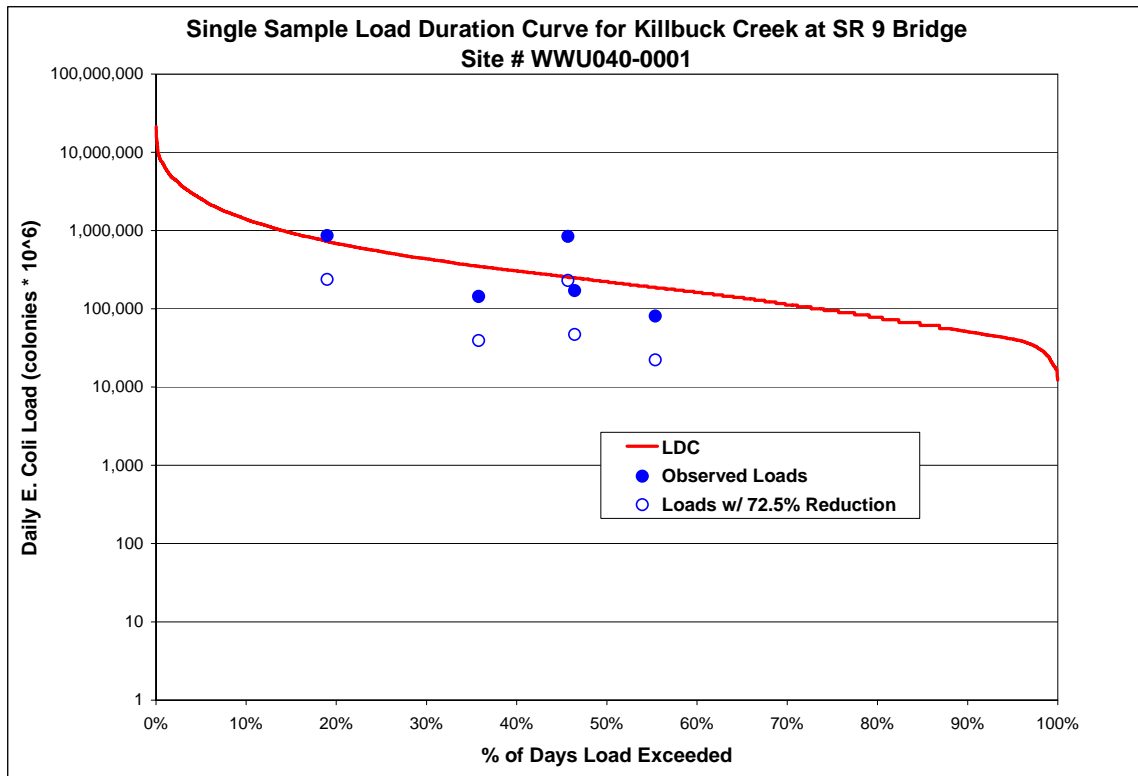




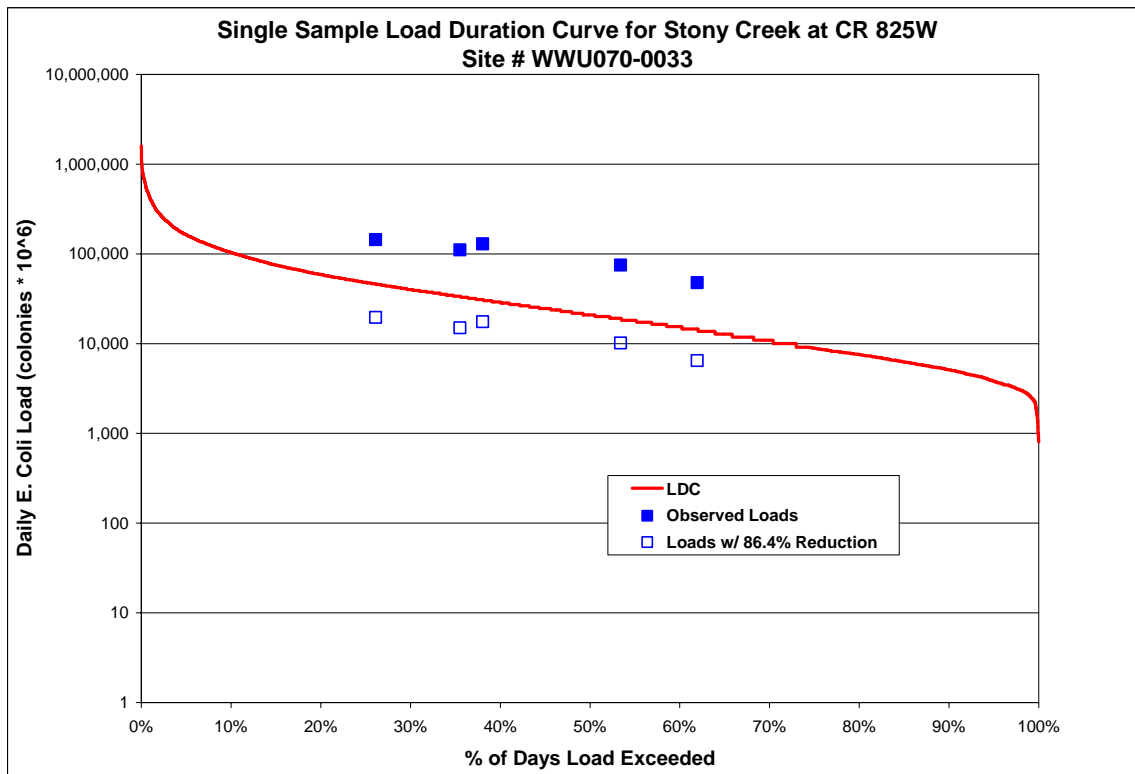
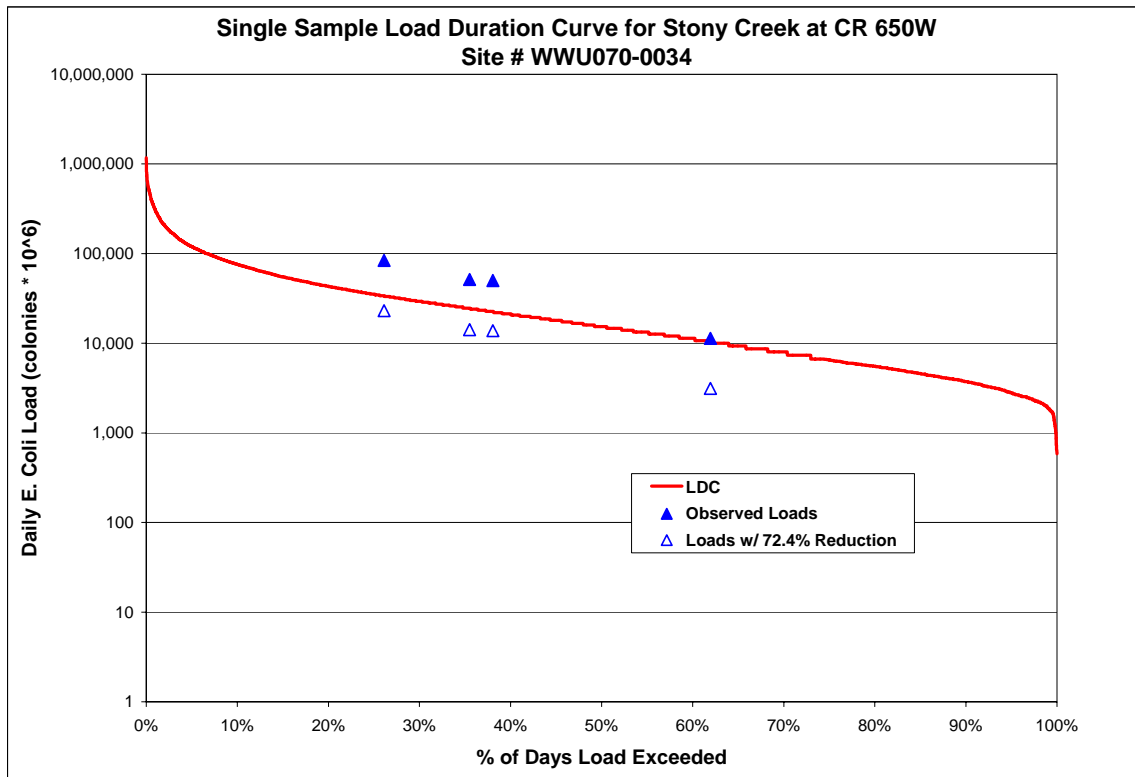


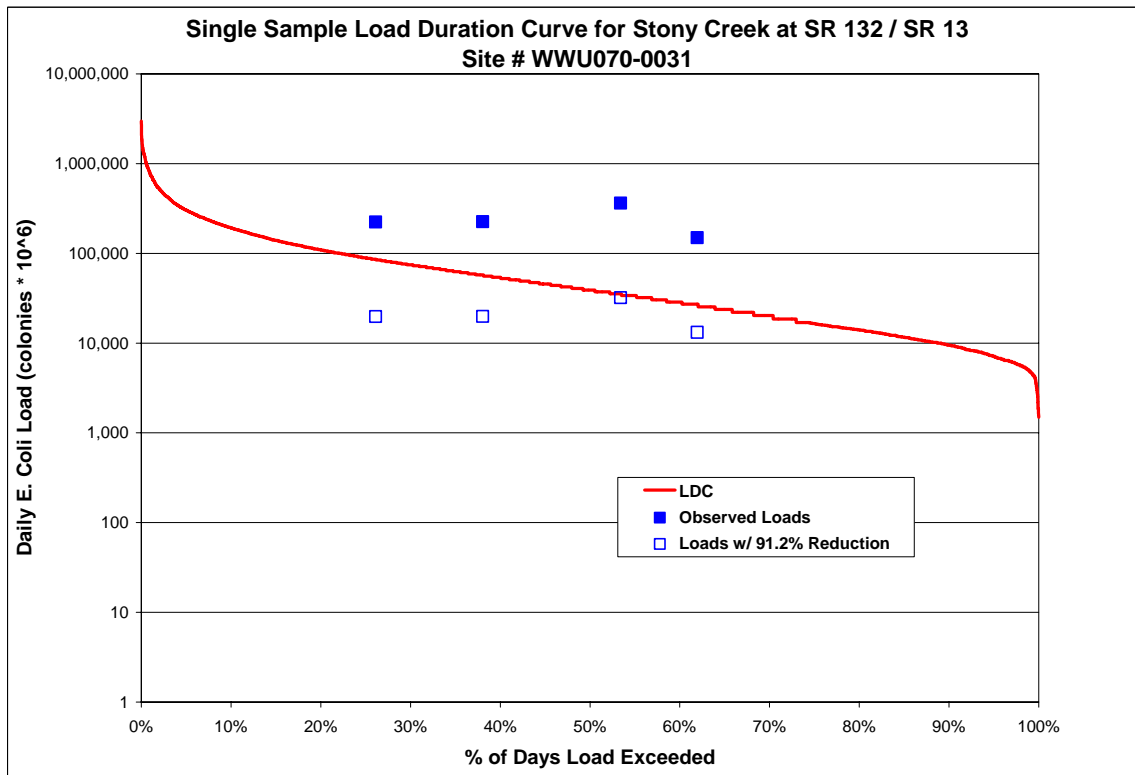
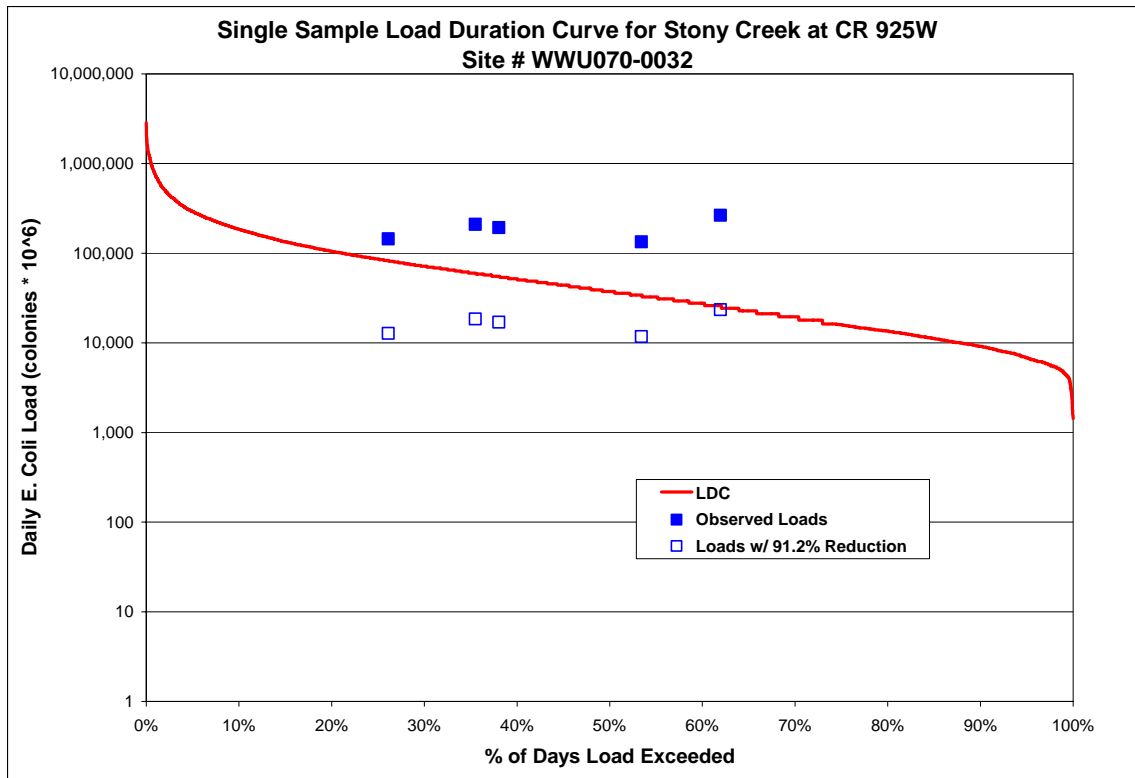


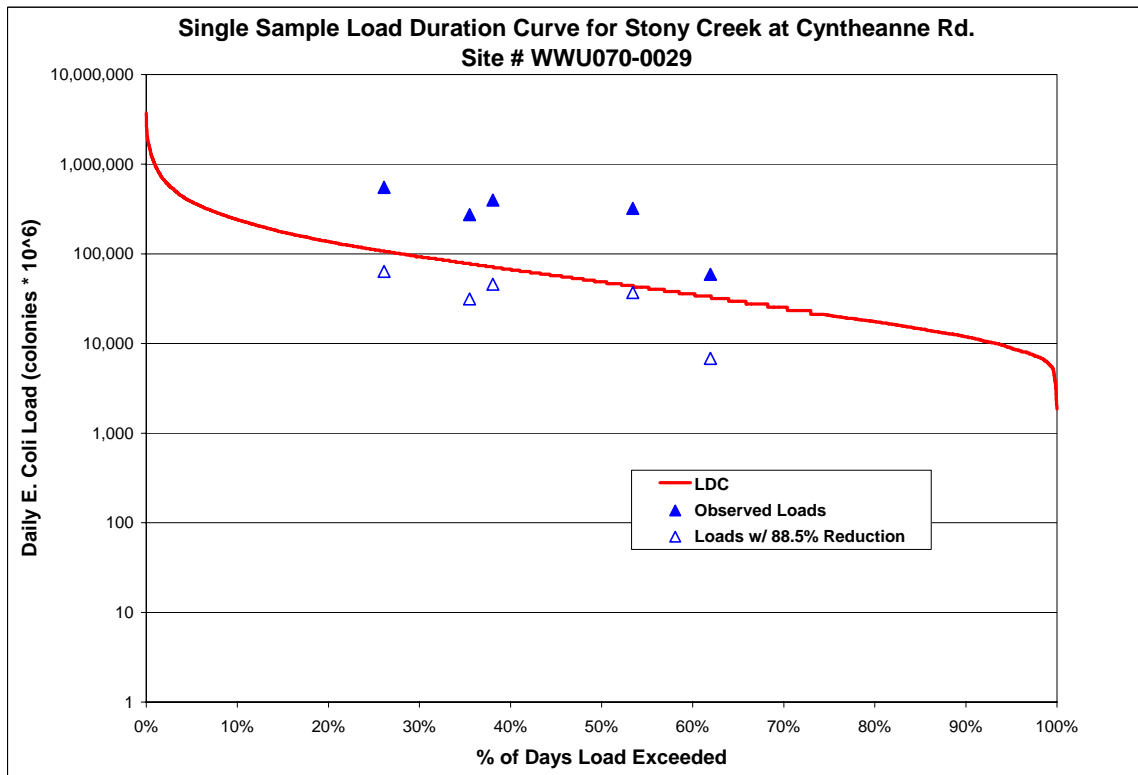
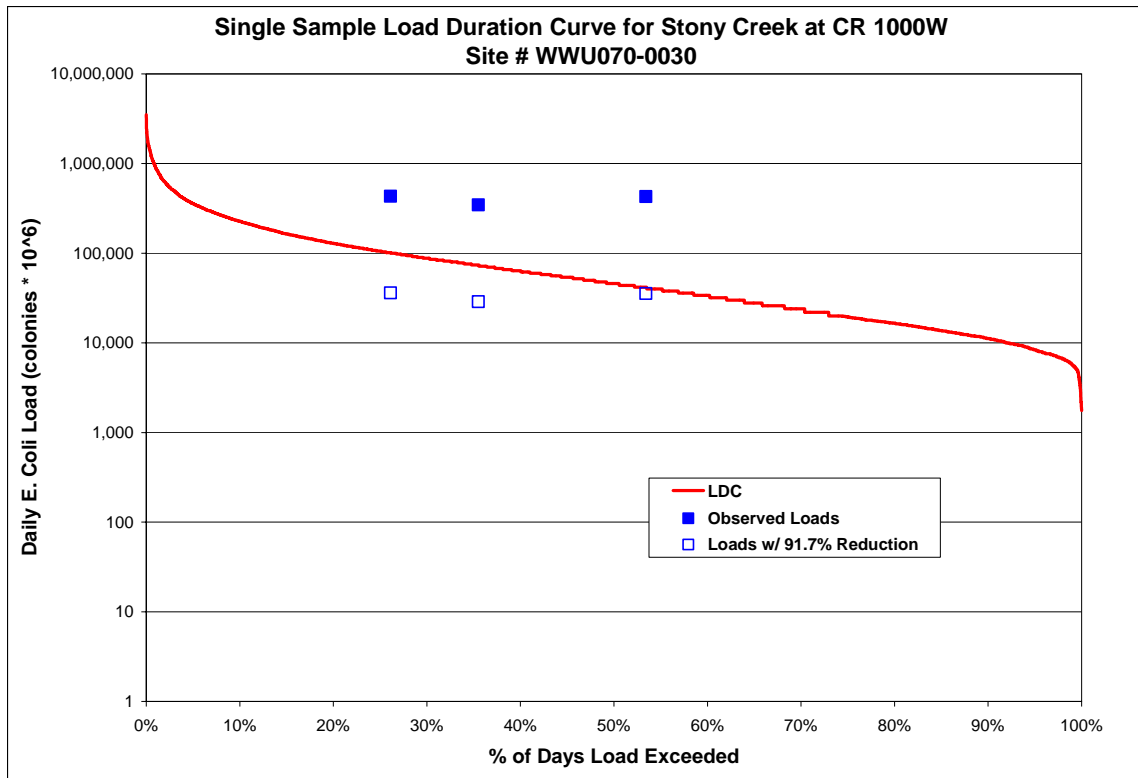


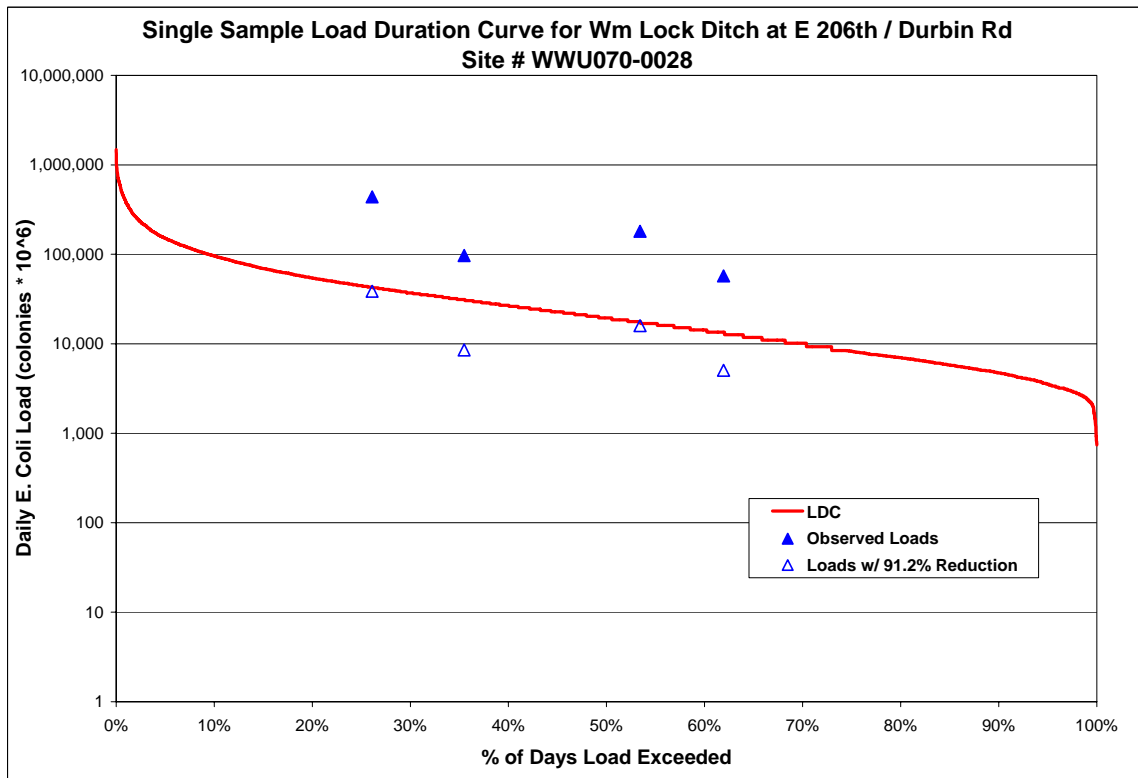
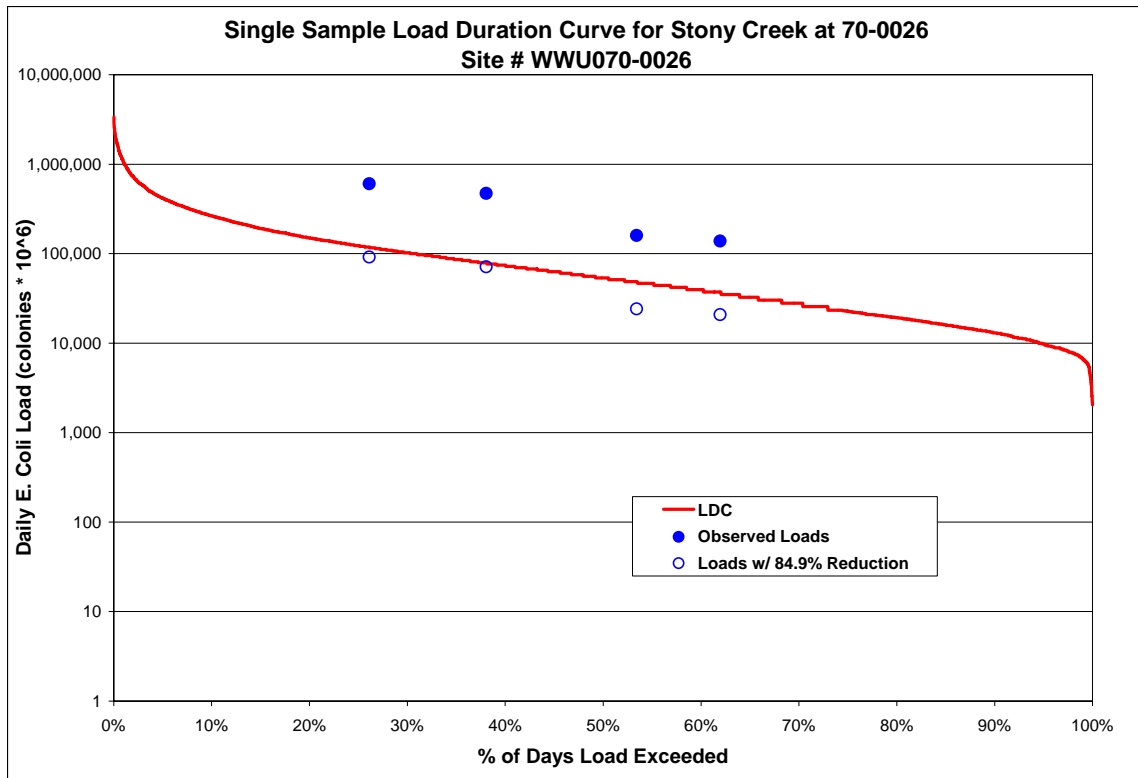


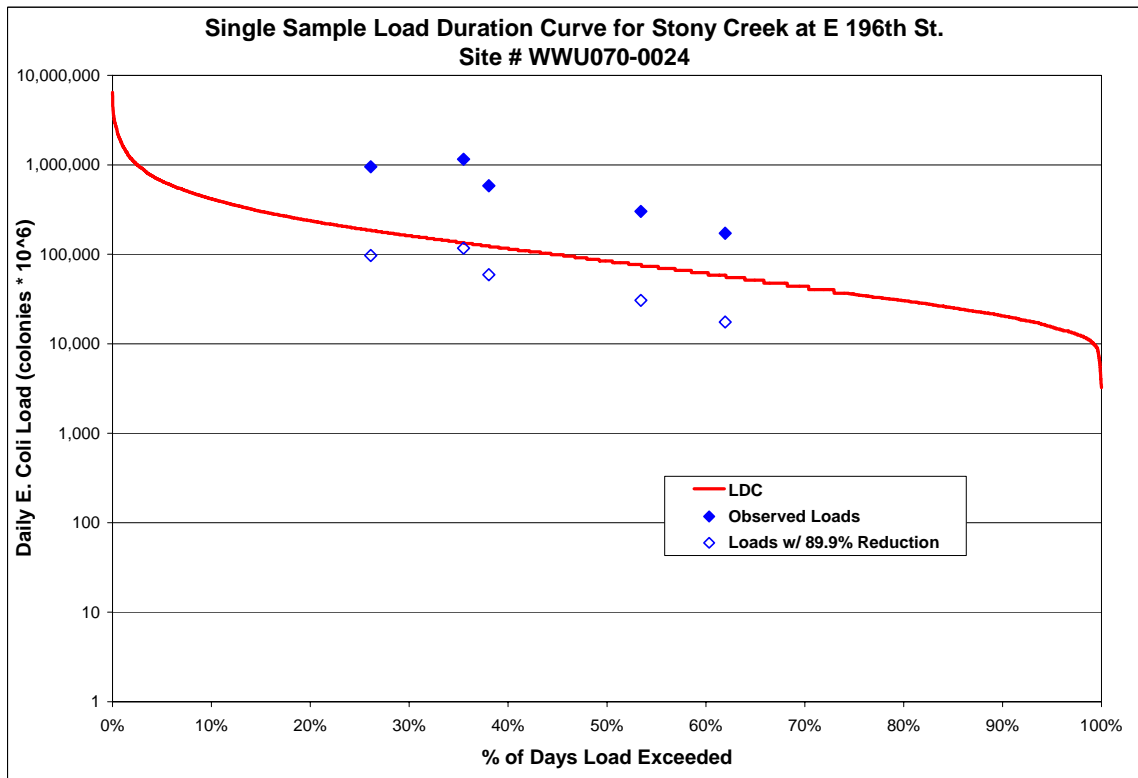
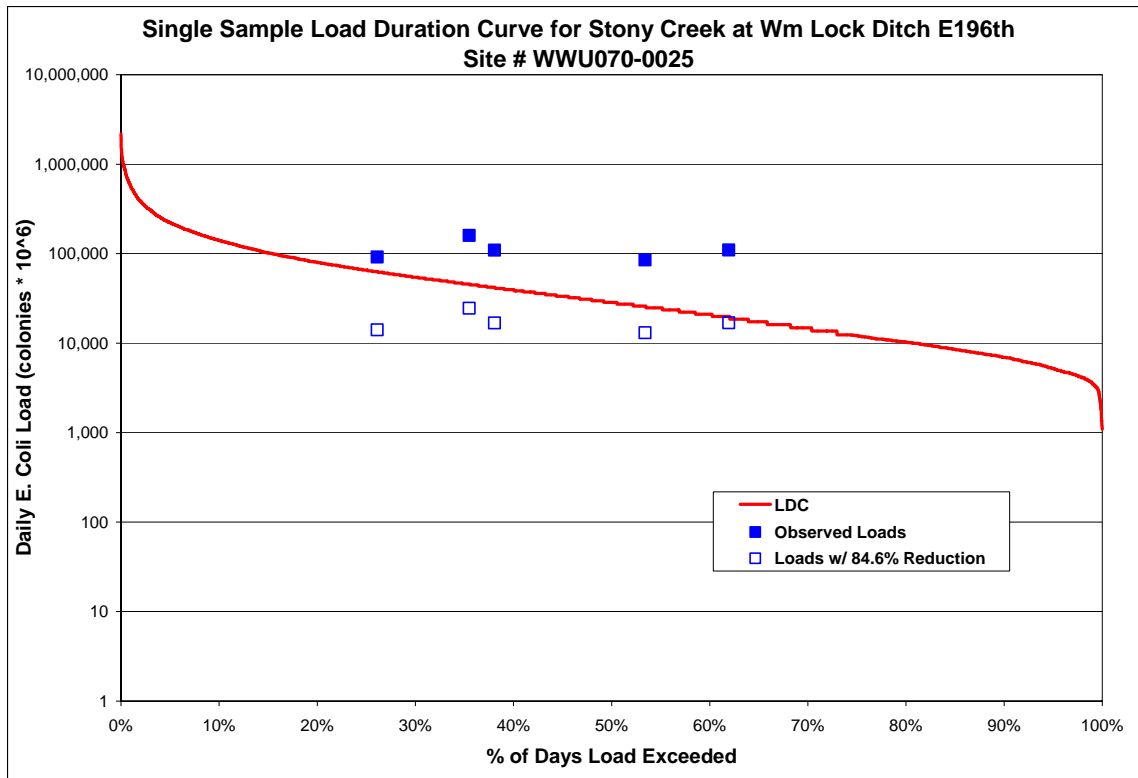
Single Sample Load Duration Curves for Stony Creek Watershed

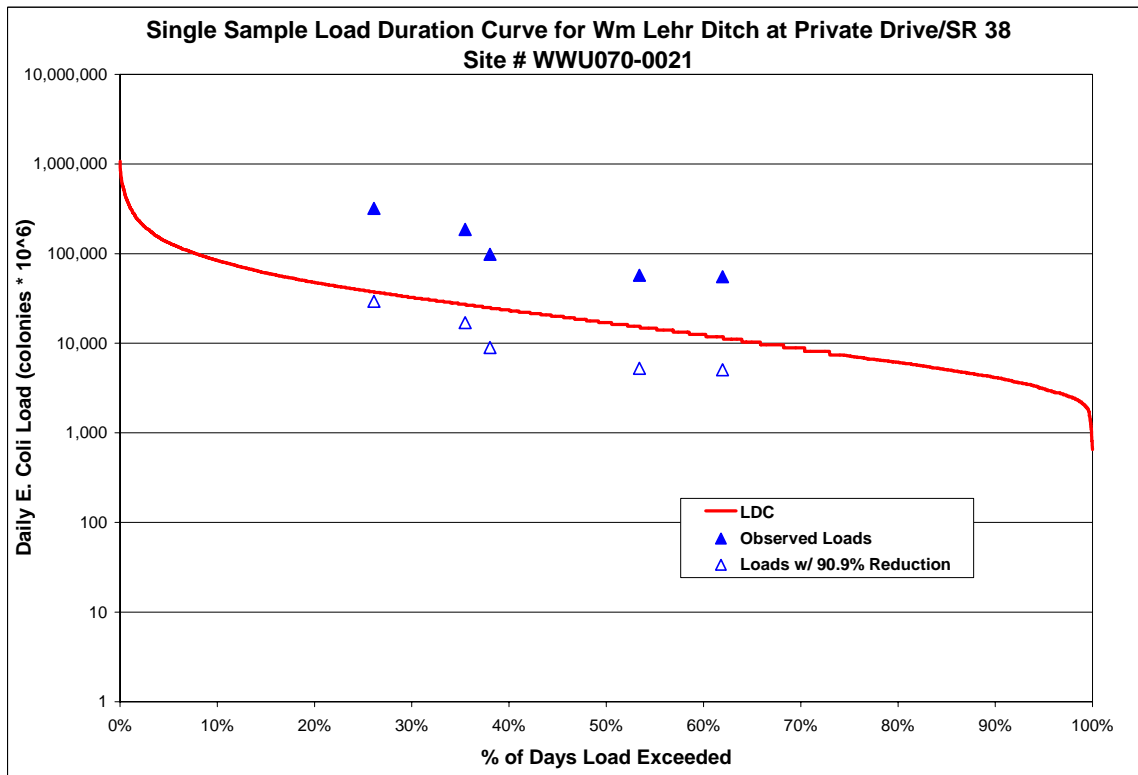
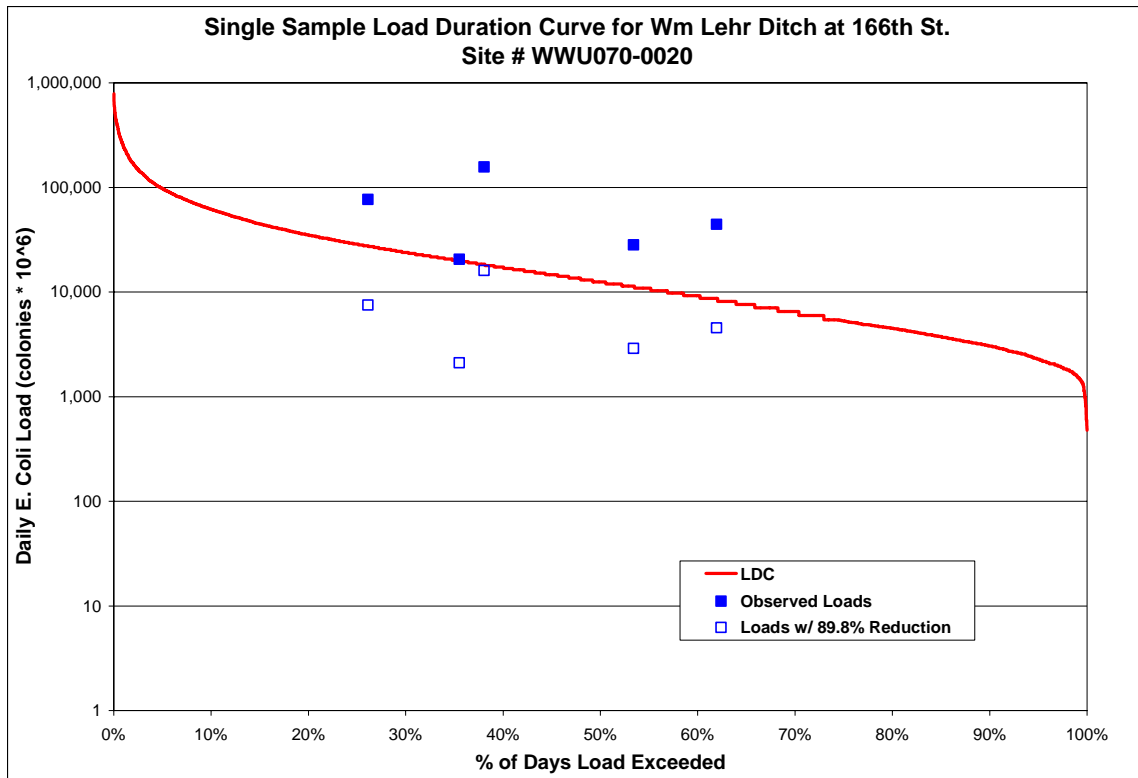


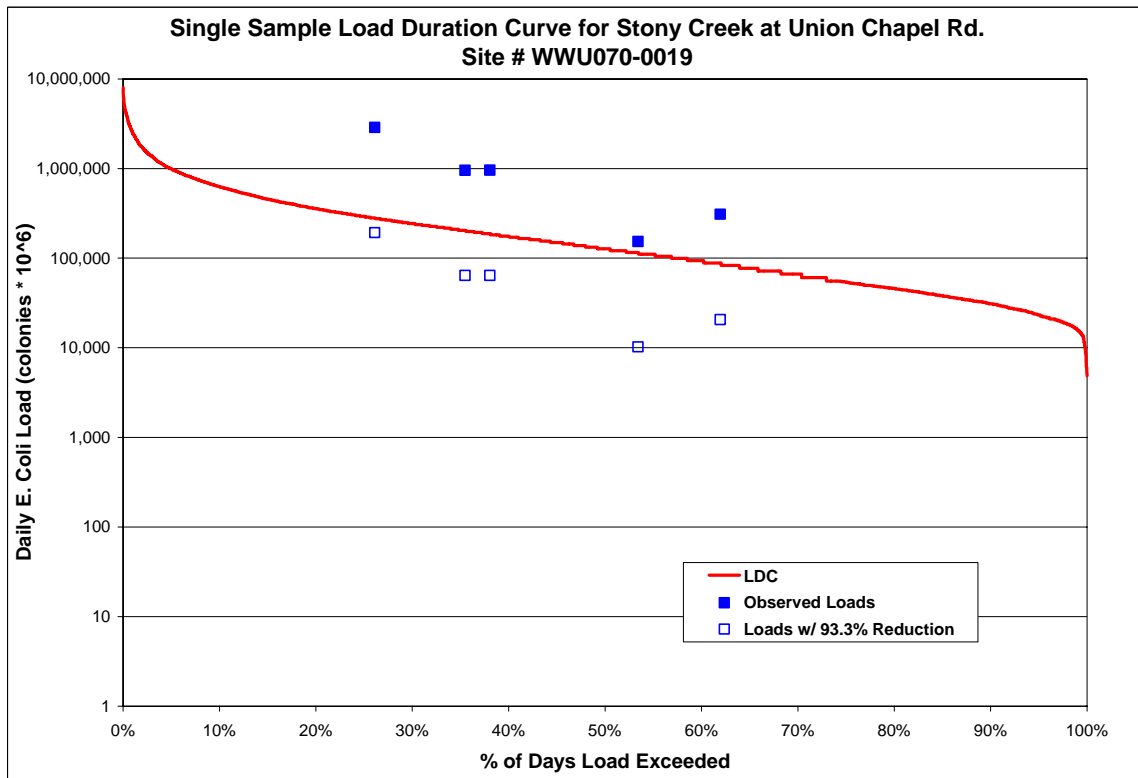
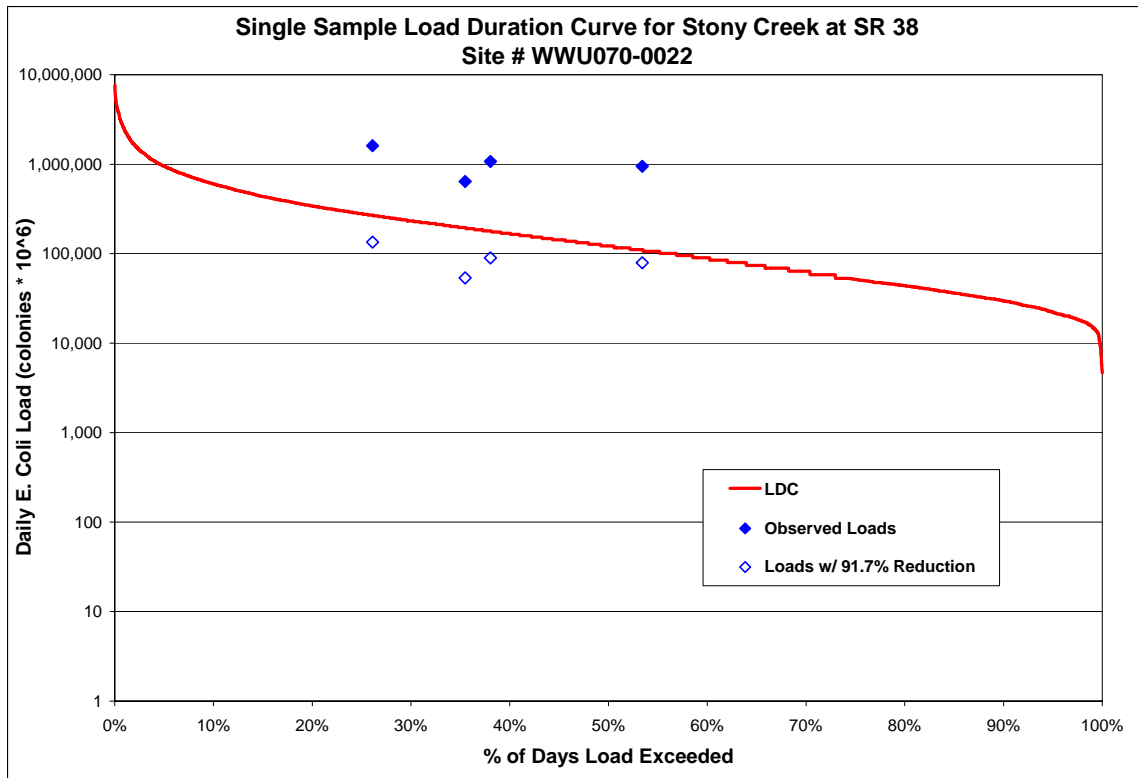


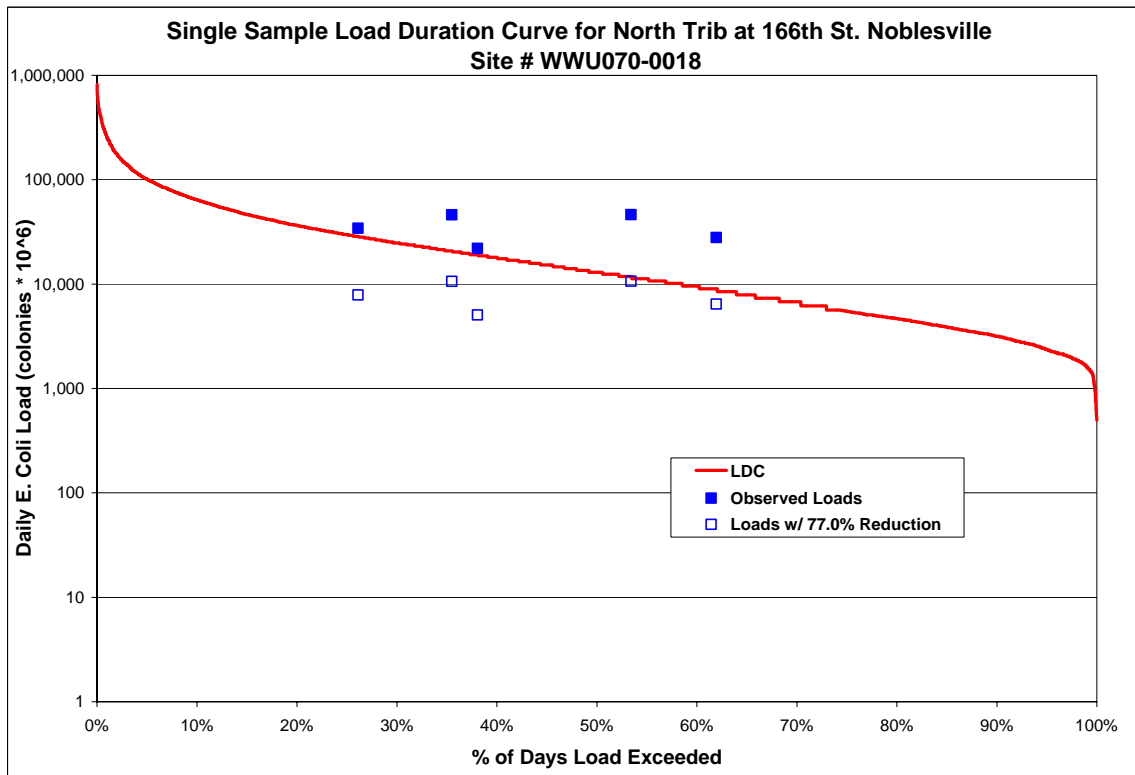
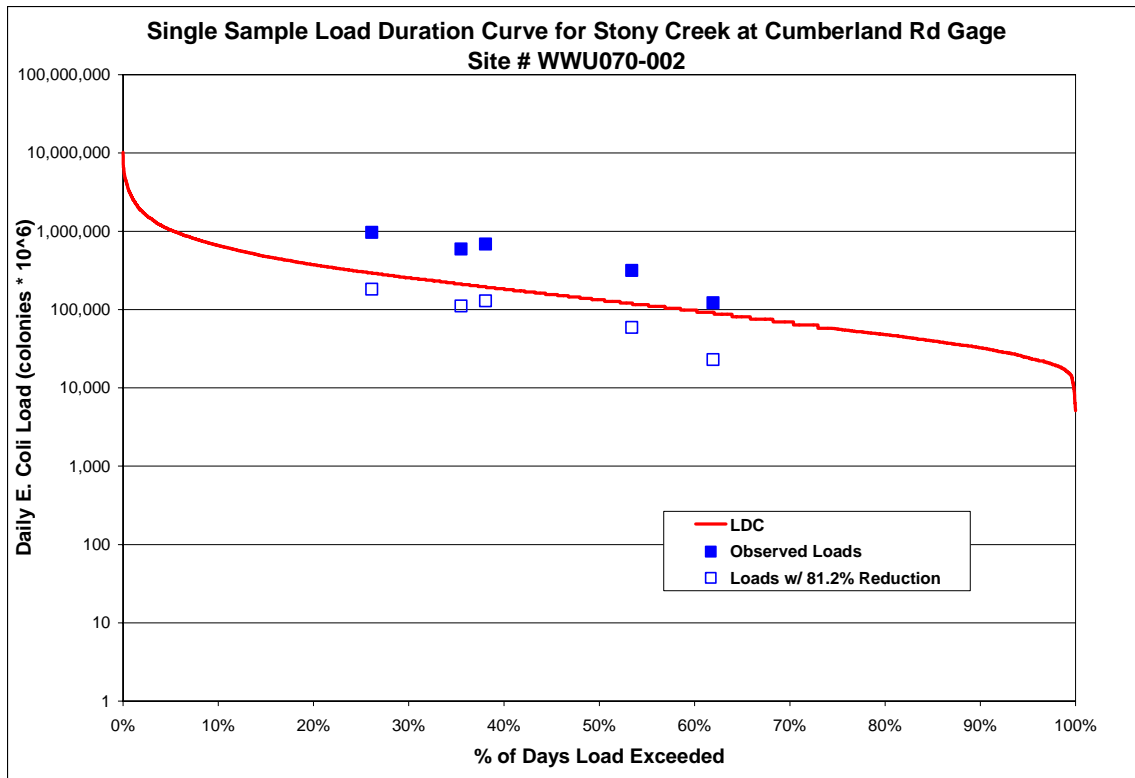


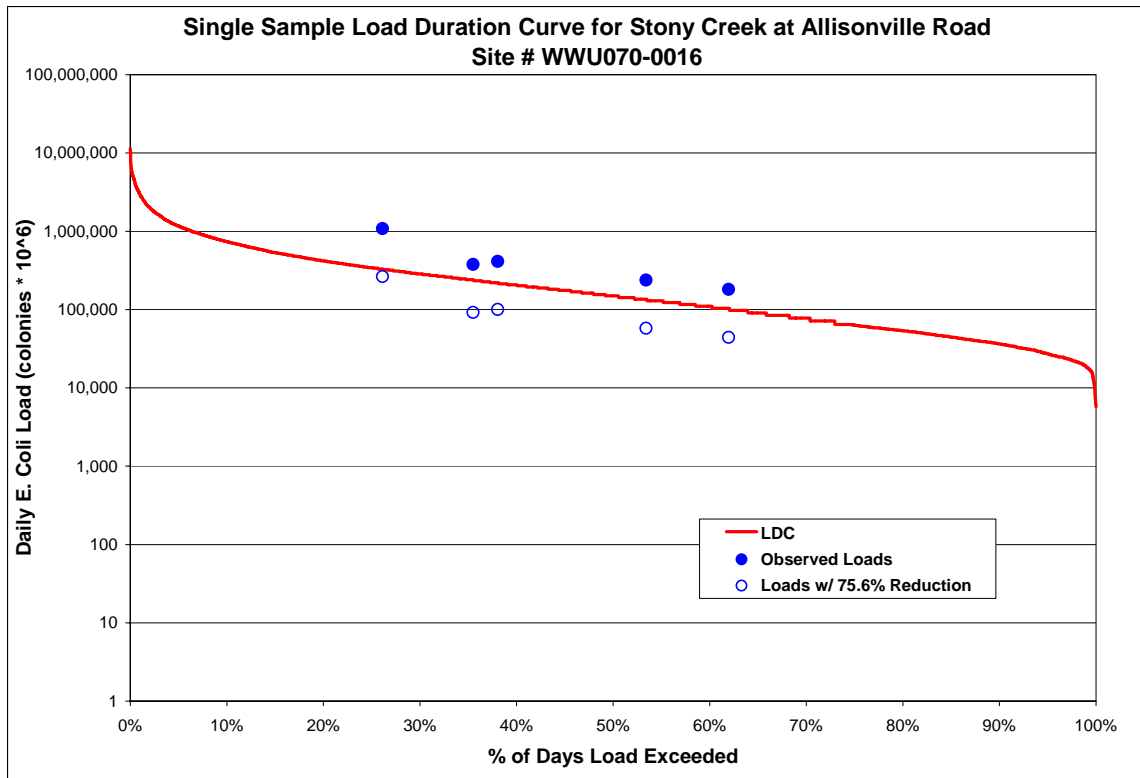








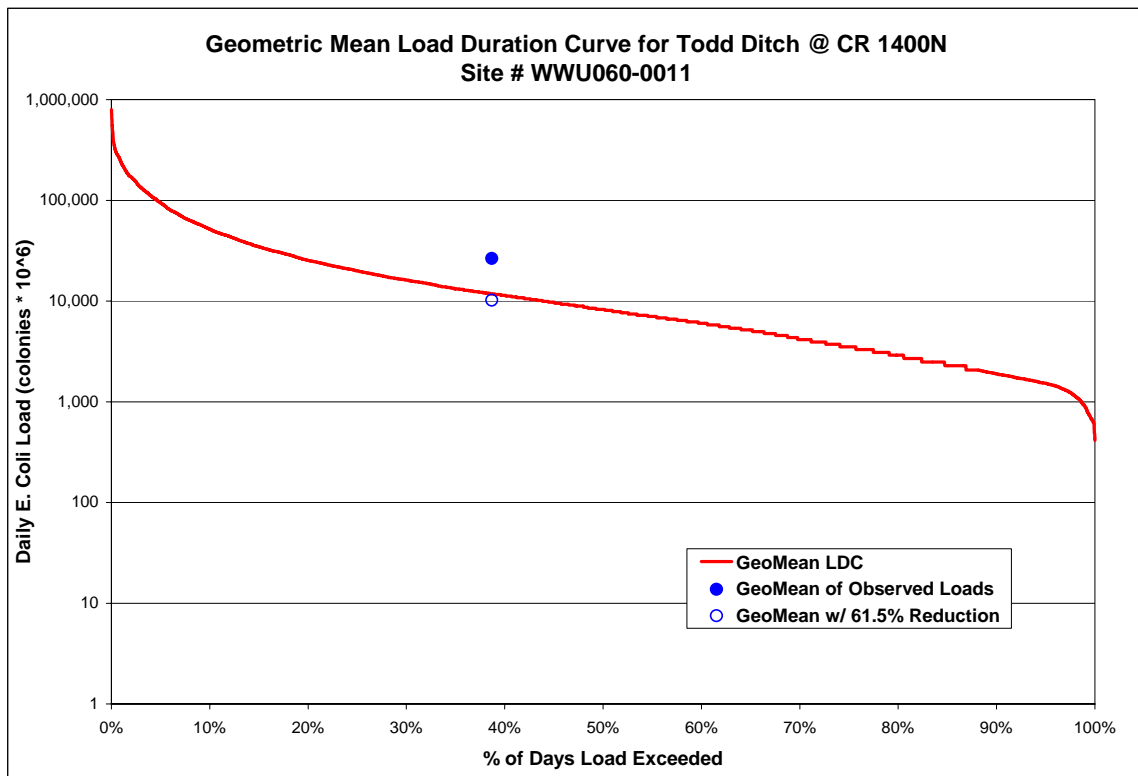
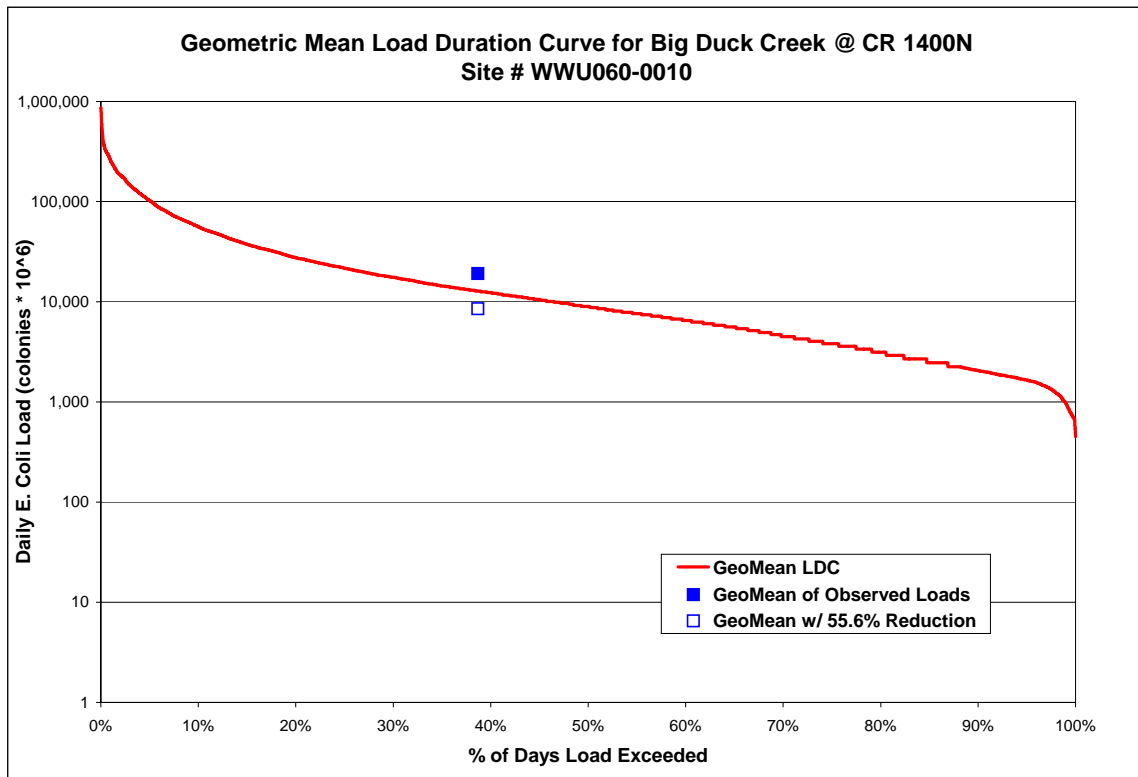


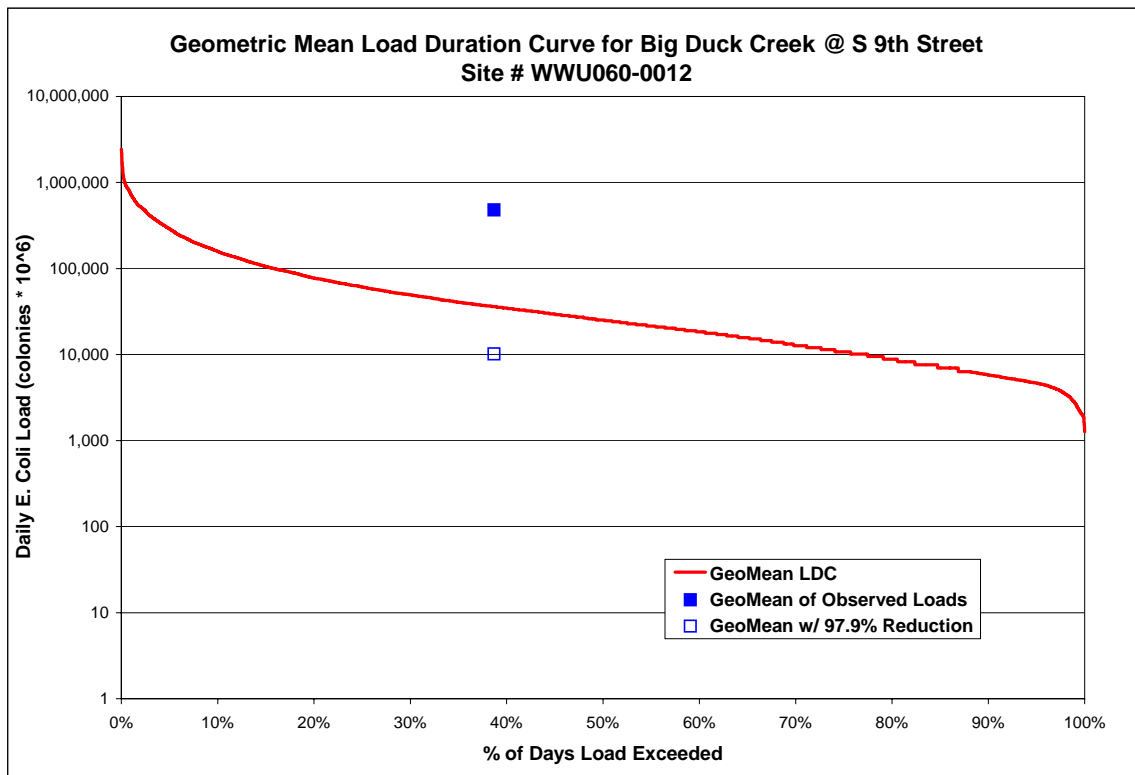
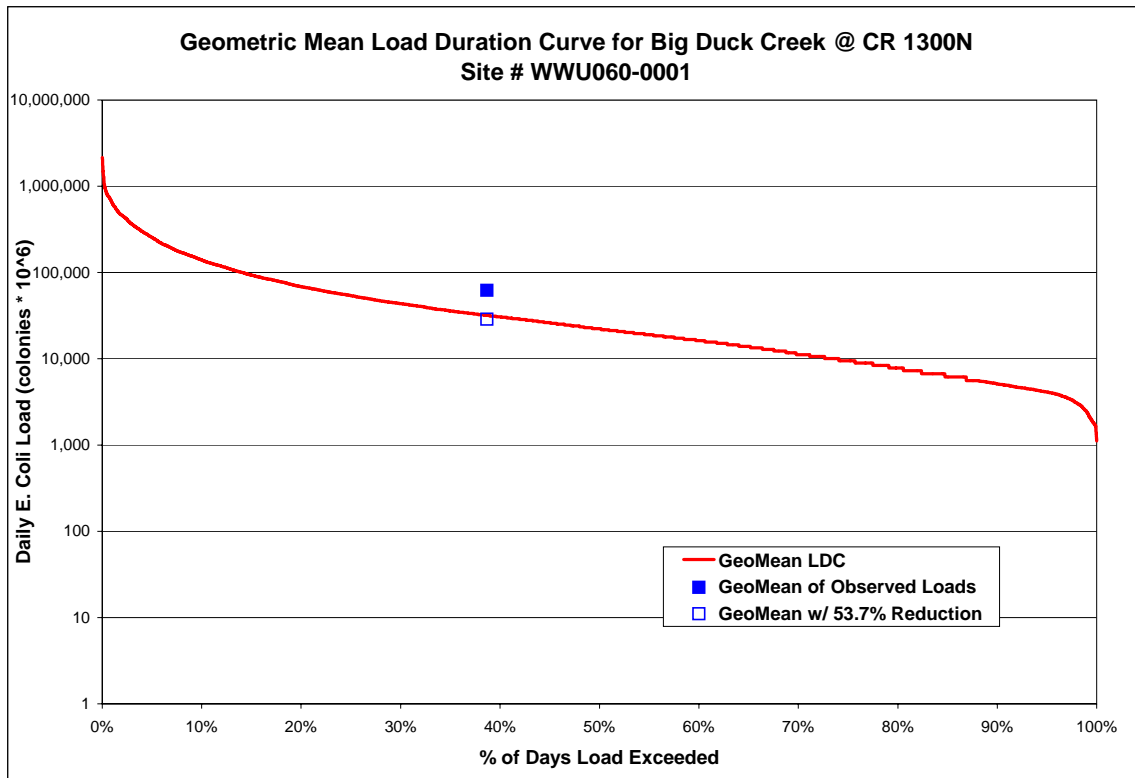


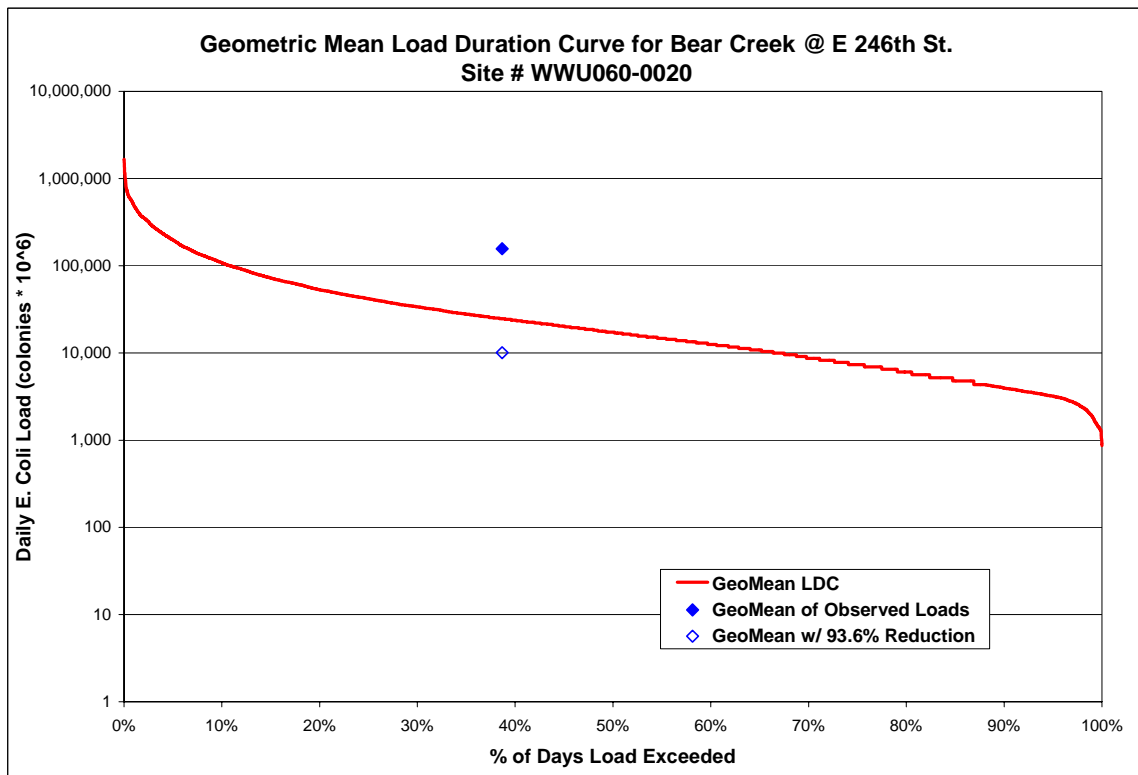
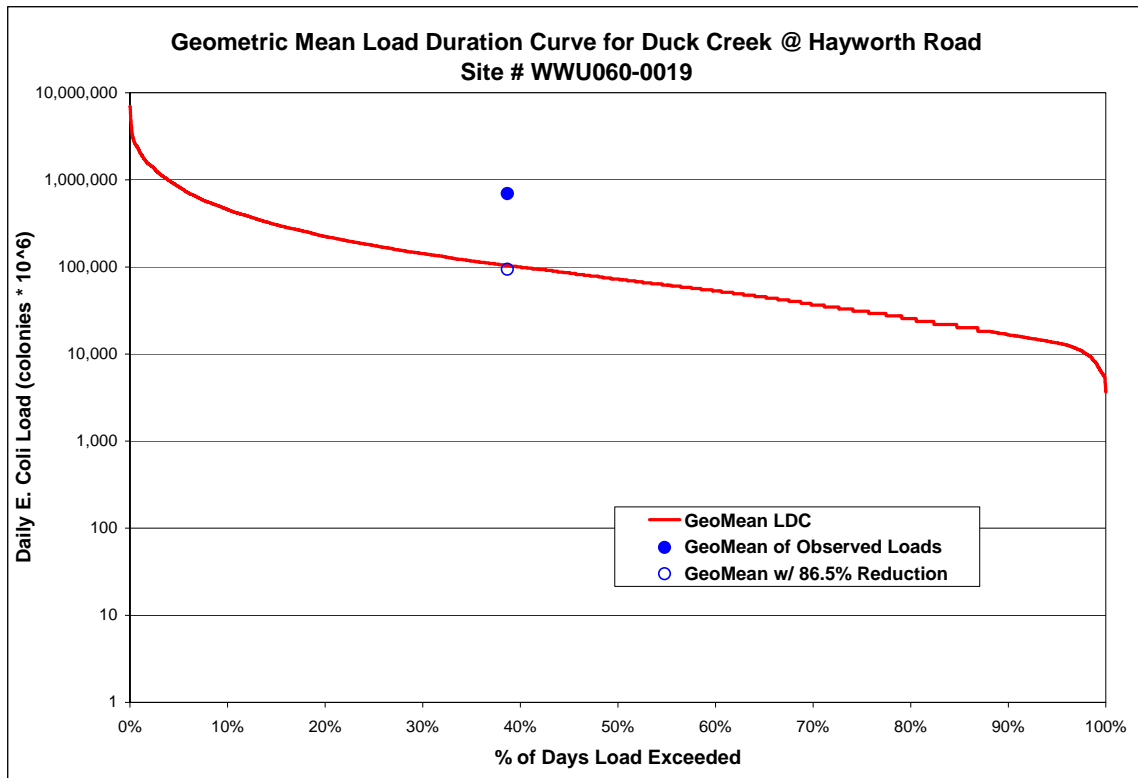
APPENDIX E

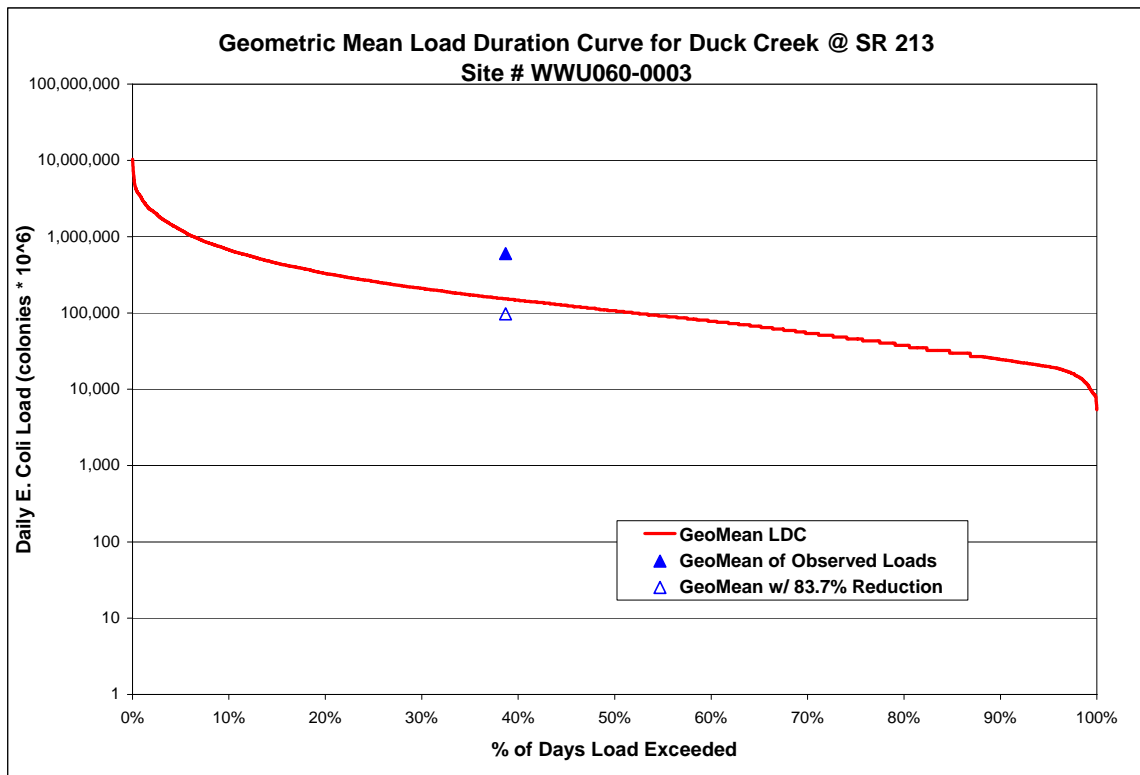
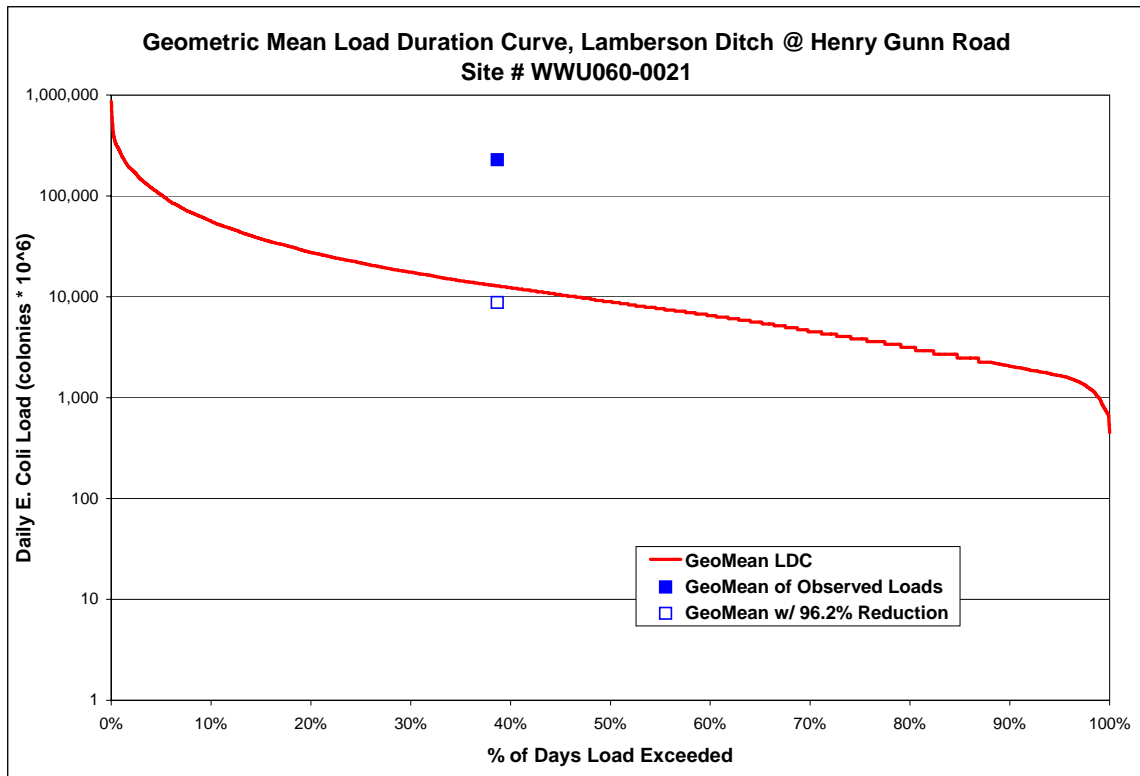
GEOMETRIC MEAN LOAD DURATION CURVES

Geometric Mean Load Duration Curves for Duck Creek Watershed

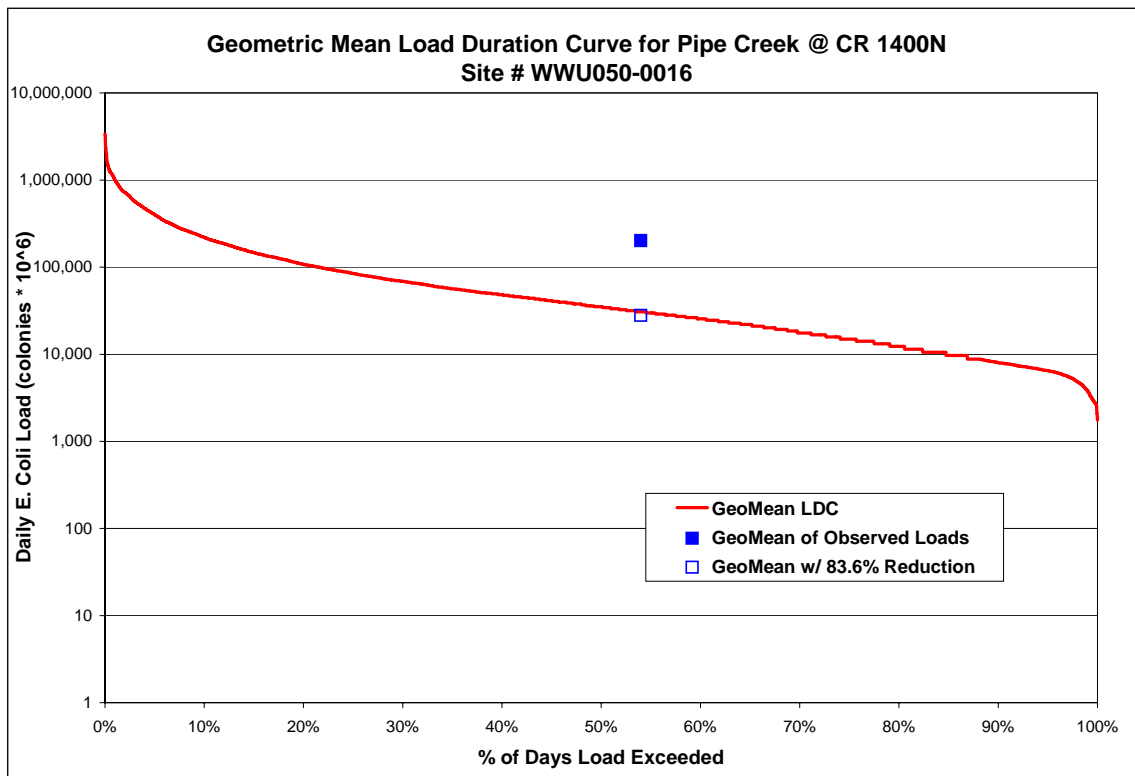
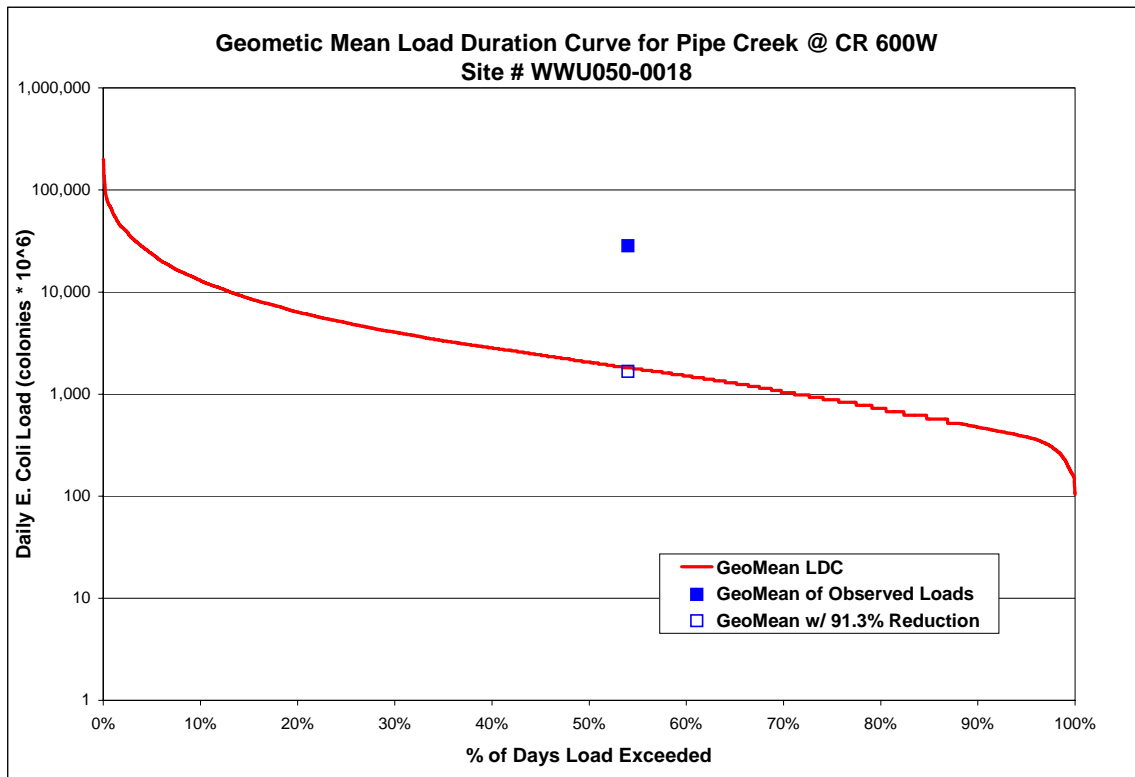


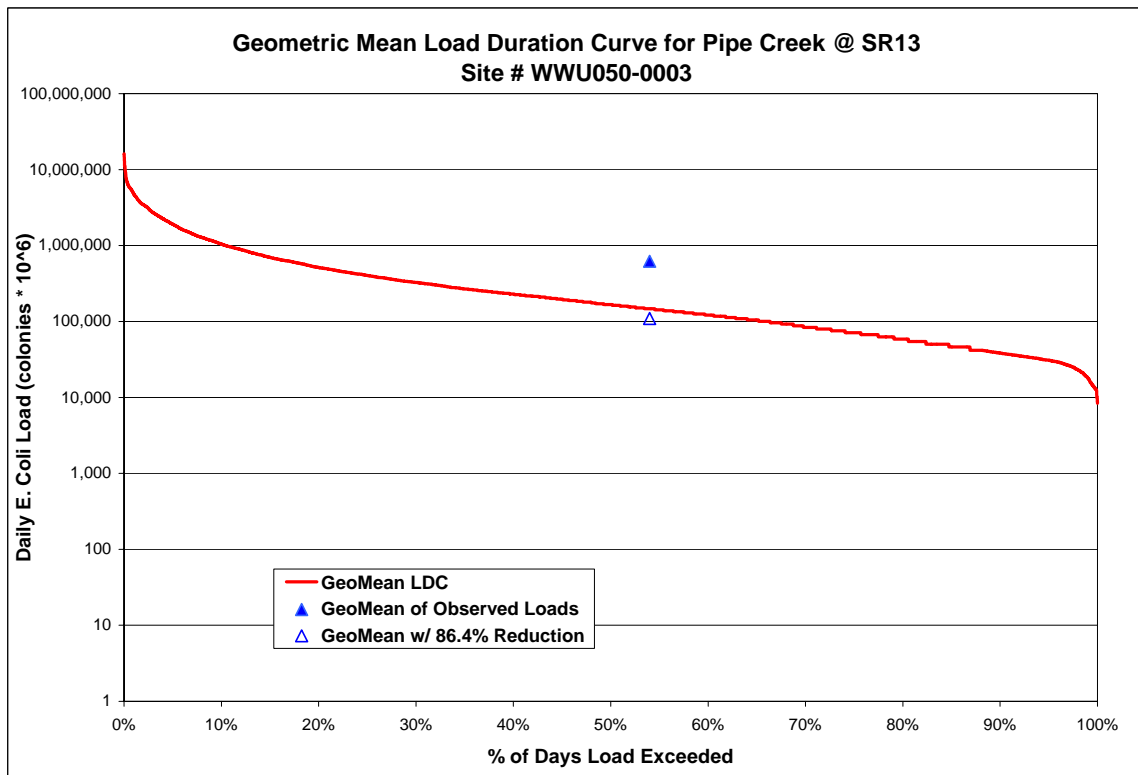
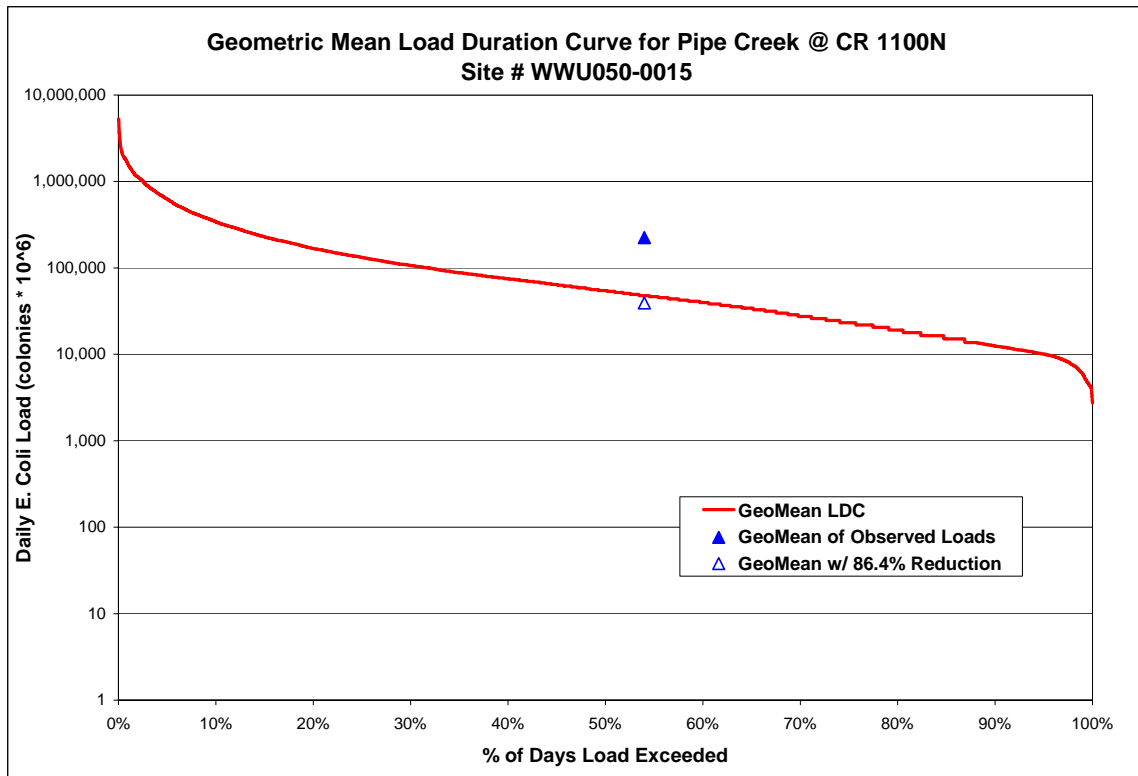




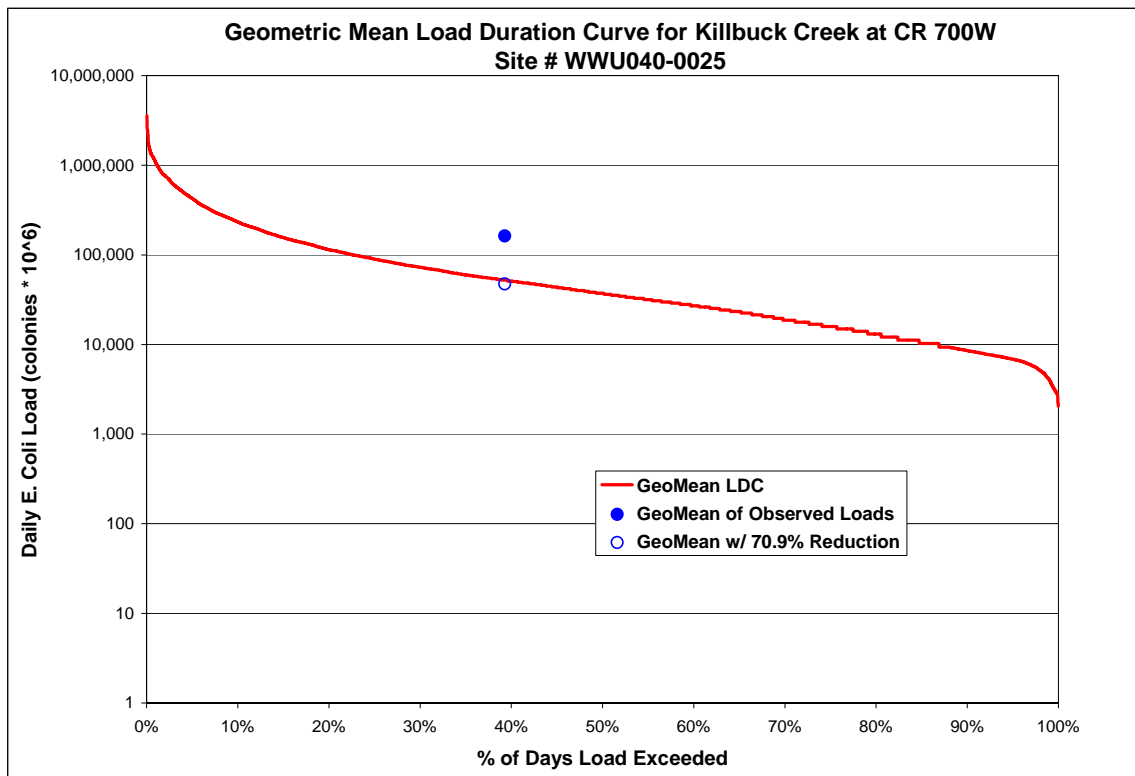
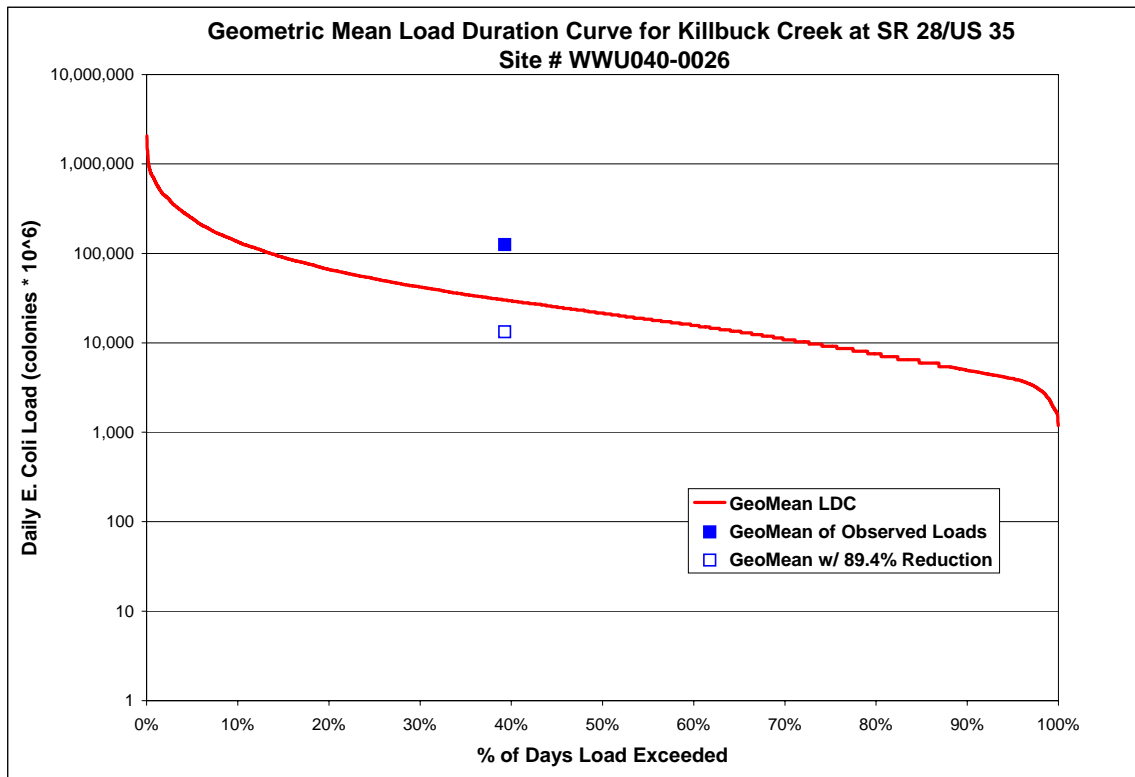


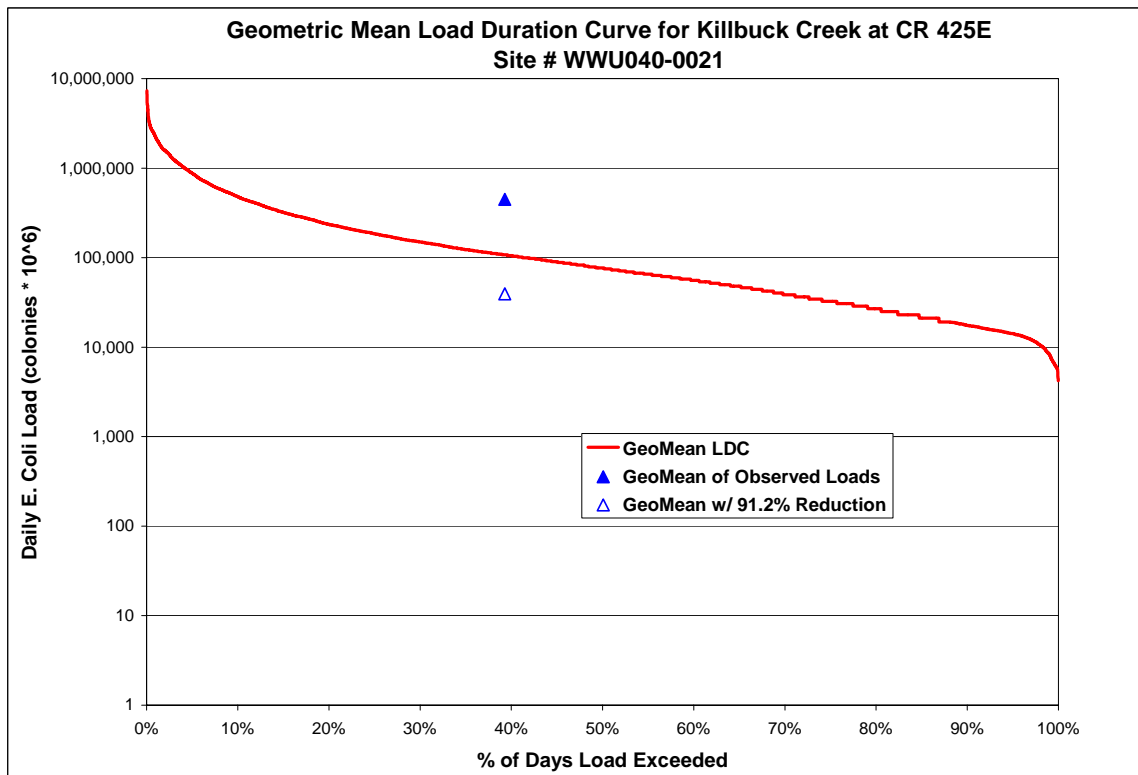
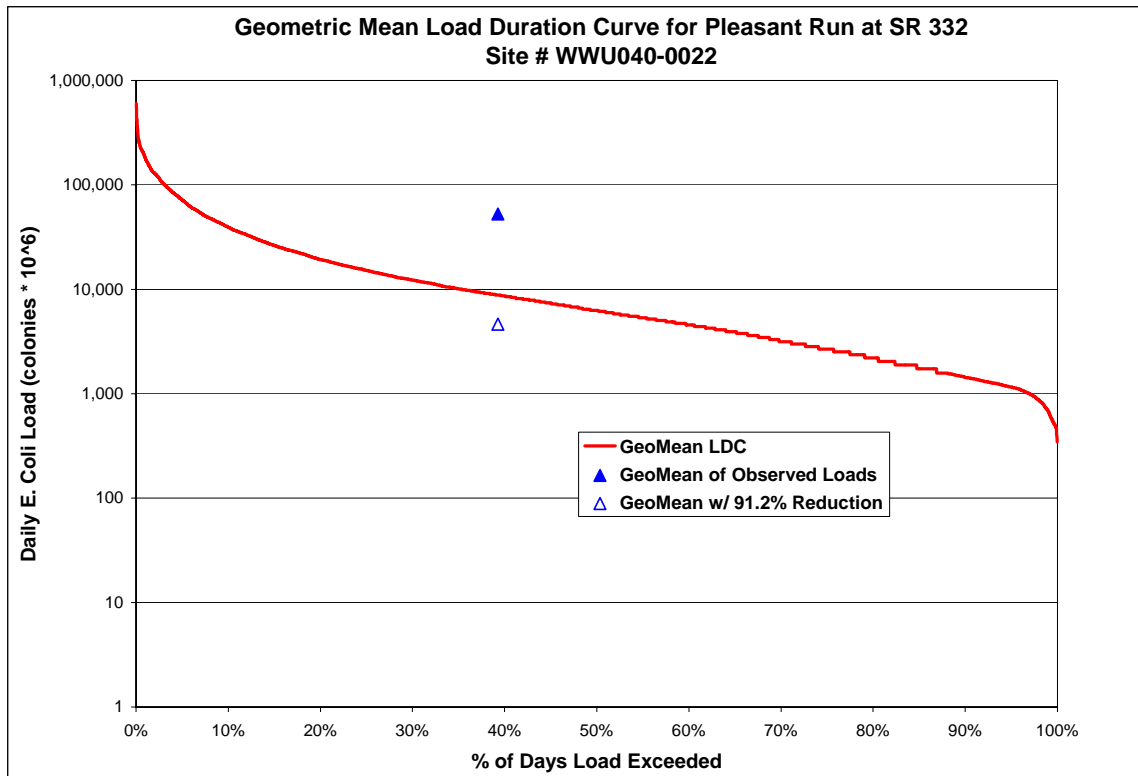
Geometric Mean Load Duration Curves for Pipe Creek Watershed

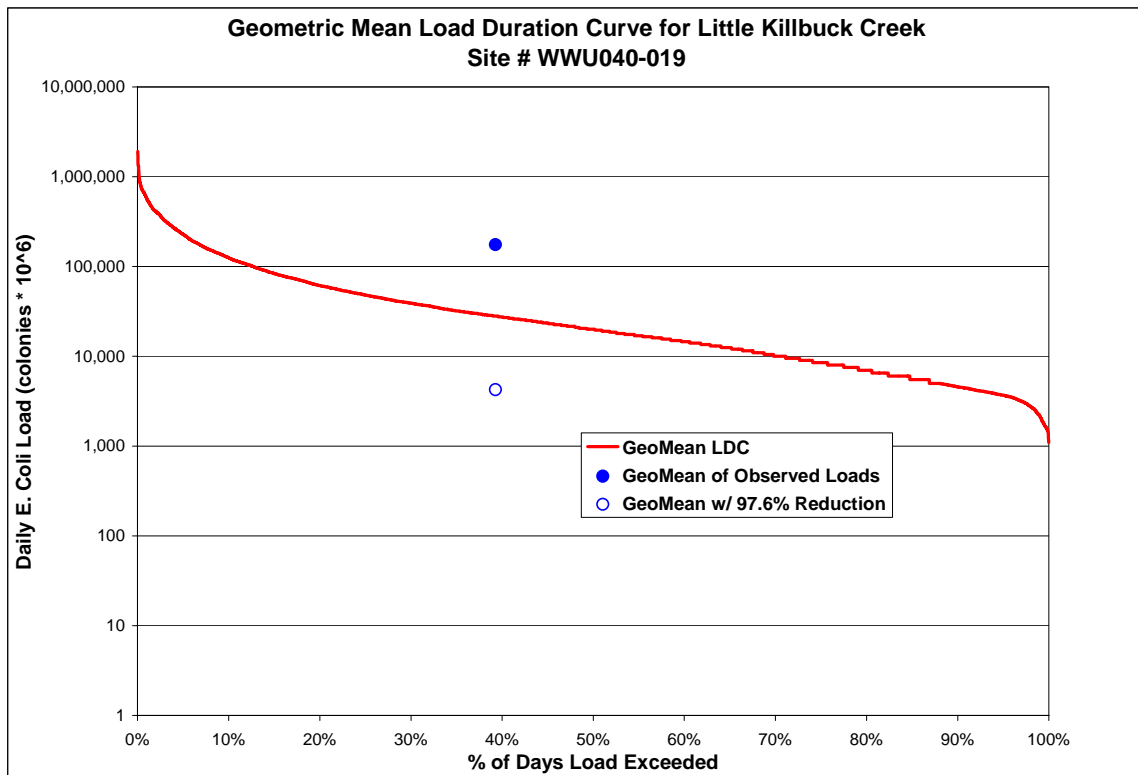
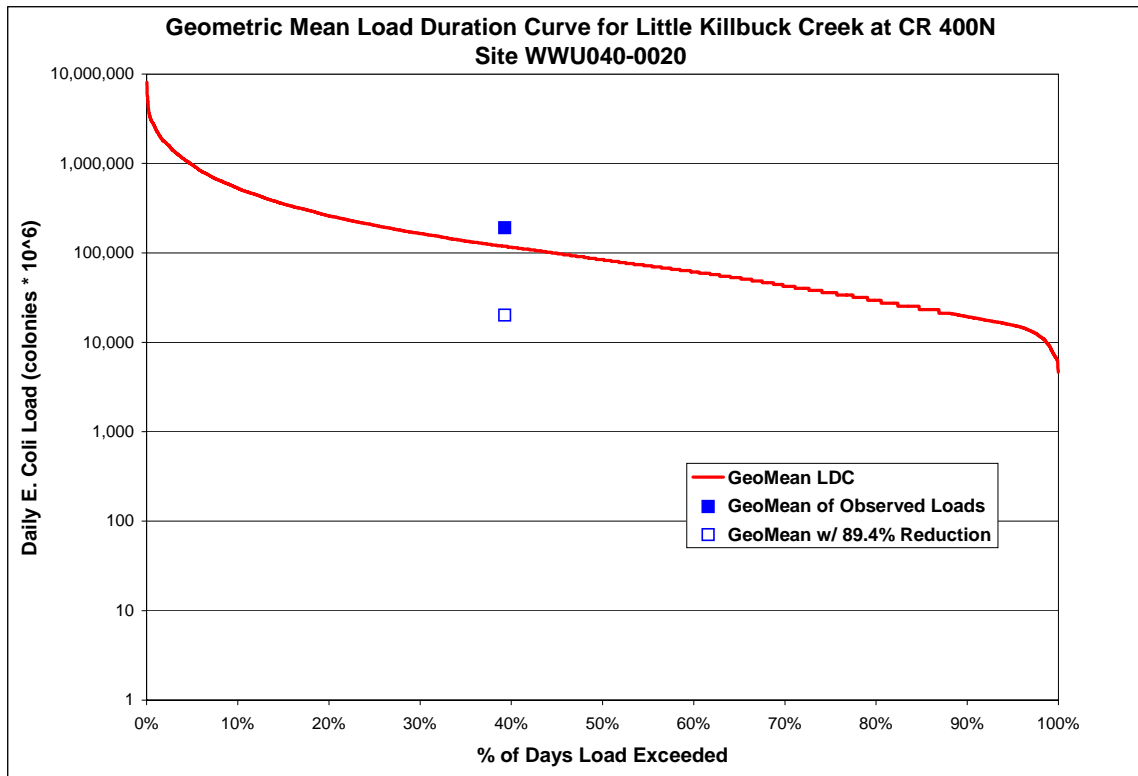


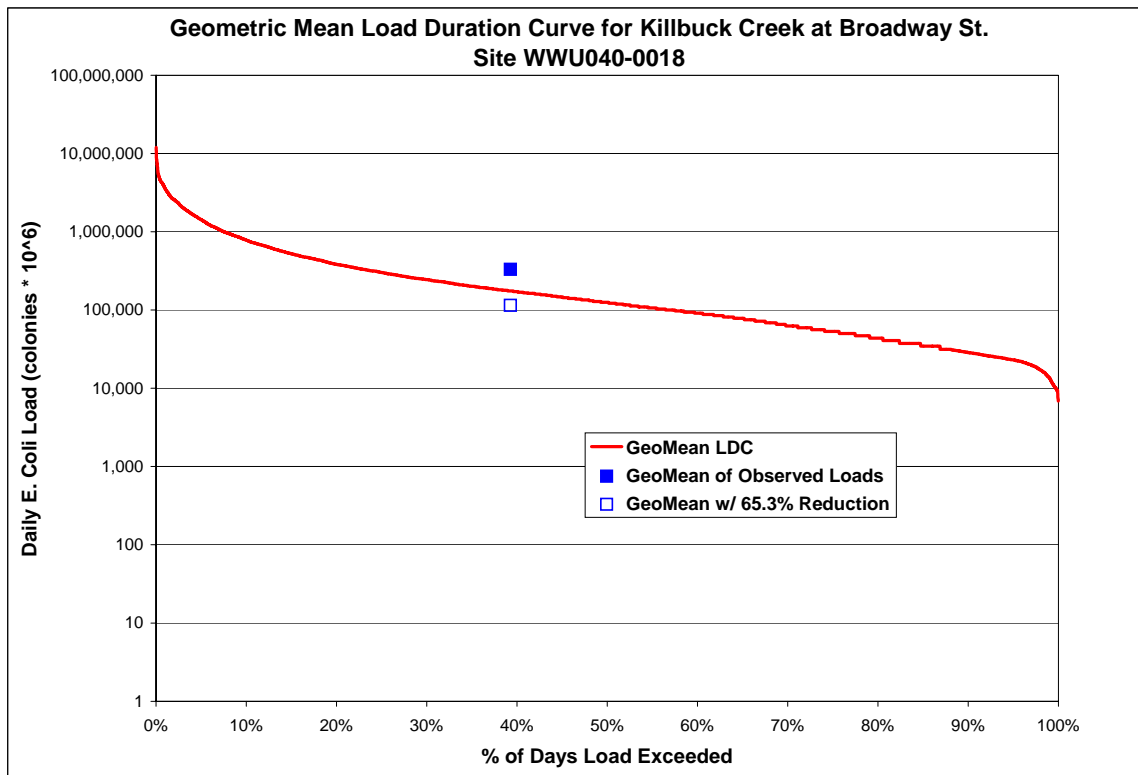
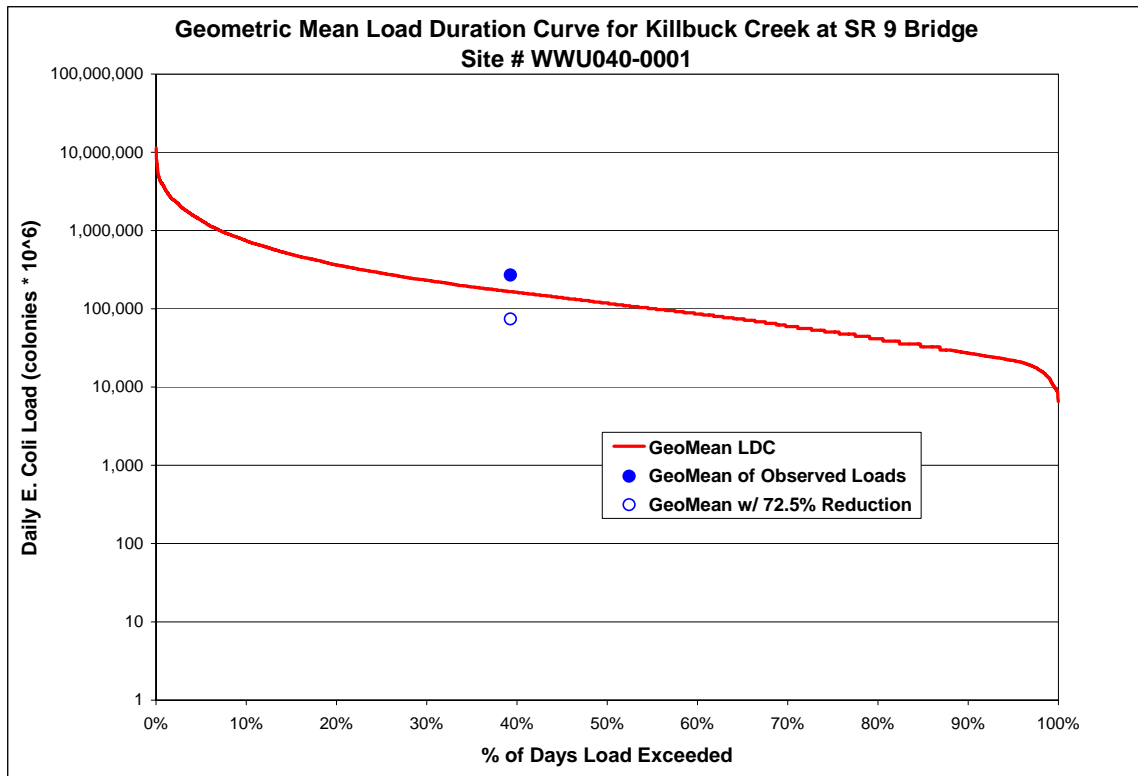


Geometric Mean Load Duration Curves for Killbuck Creek Watershed

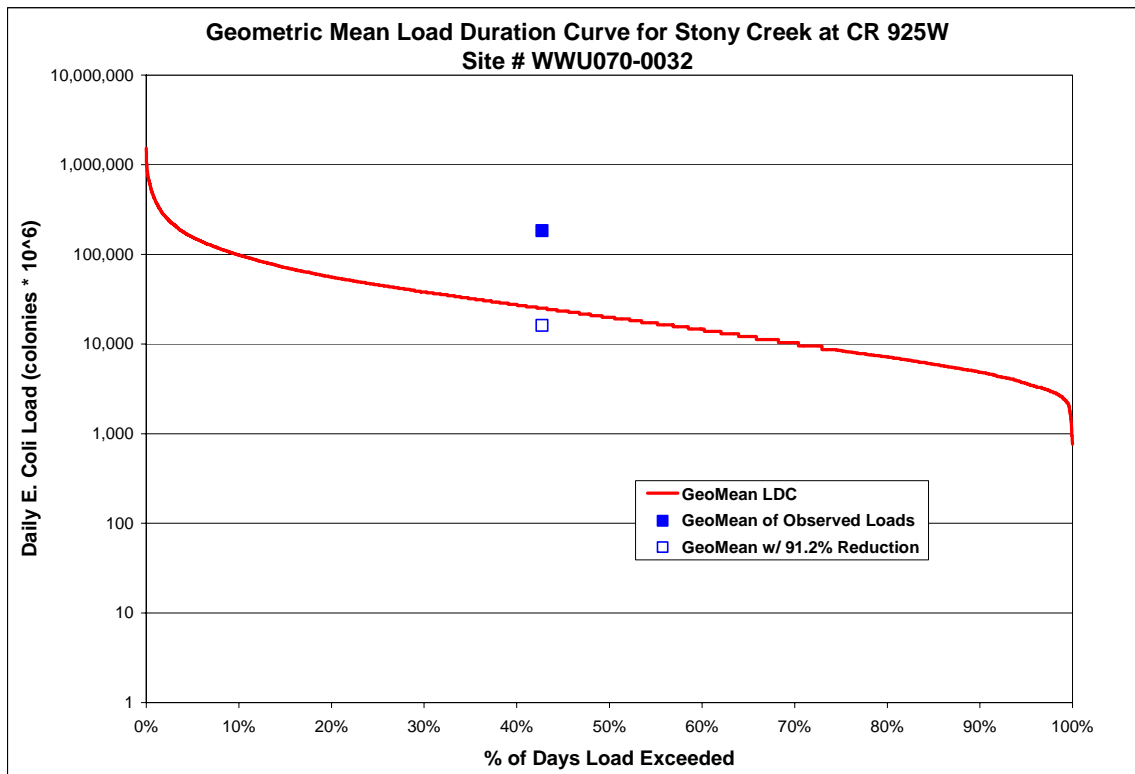
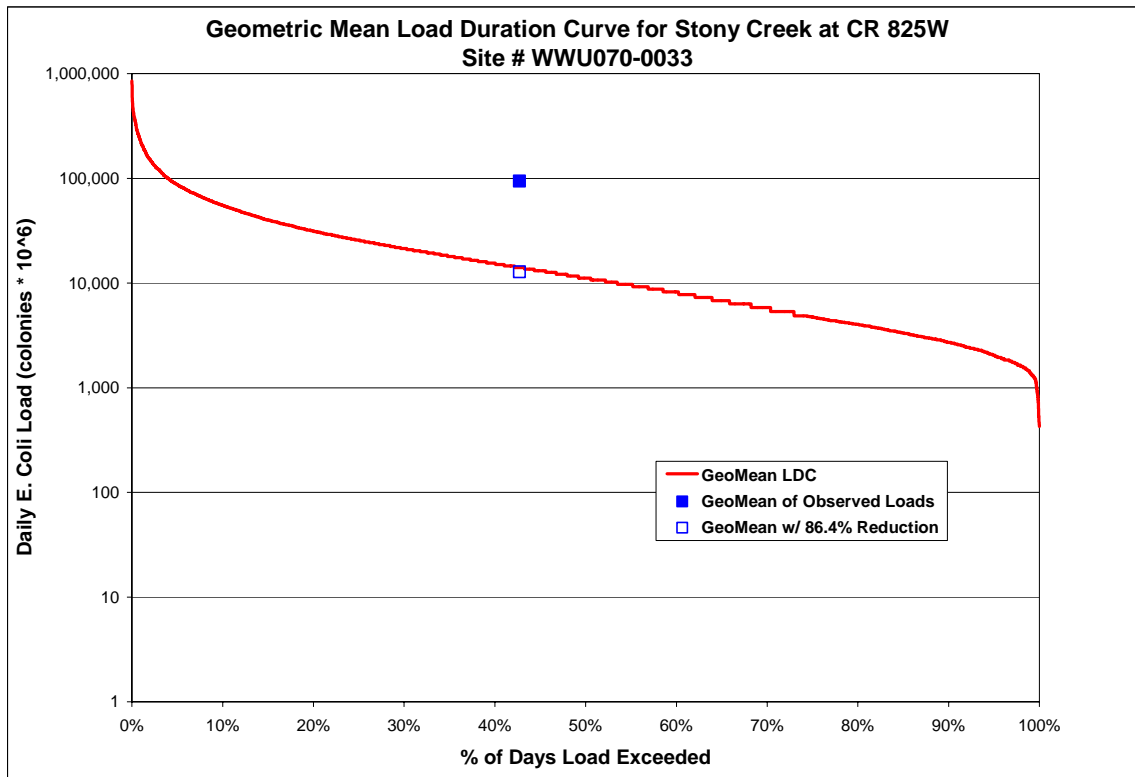


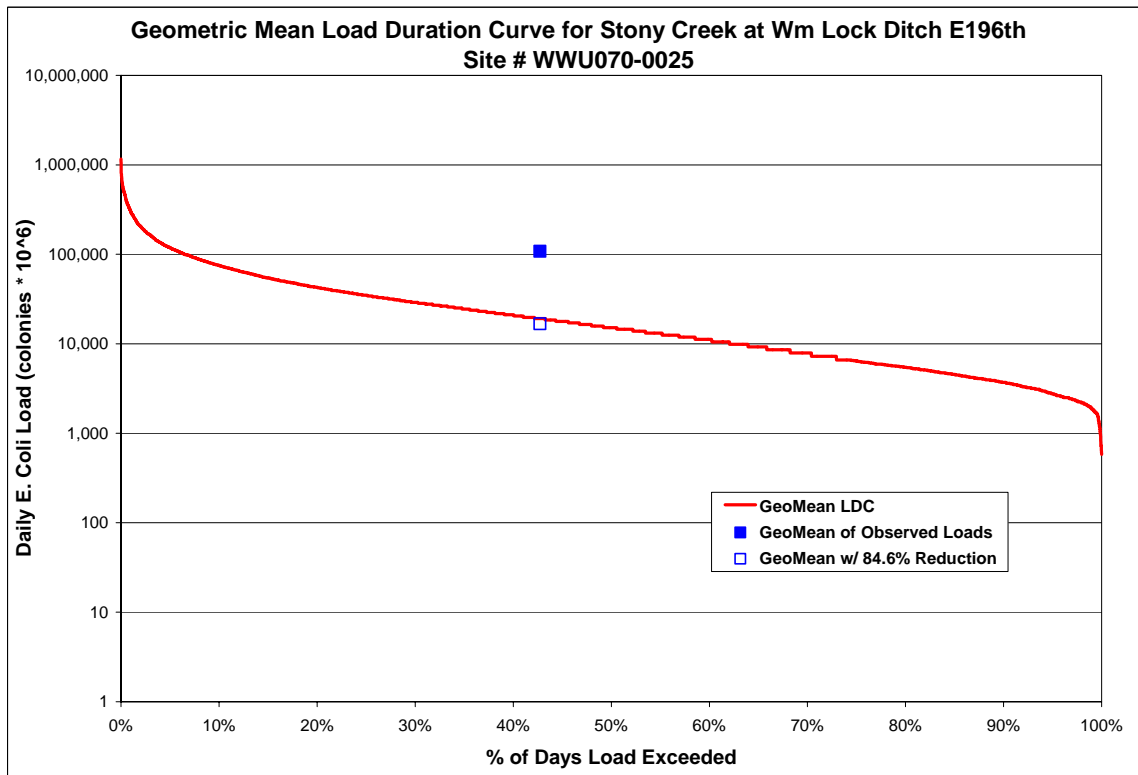
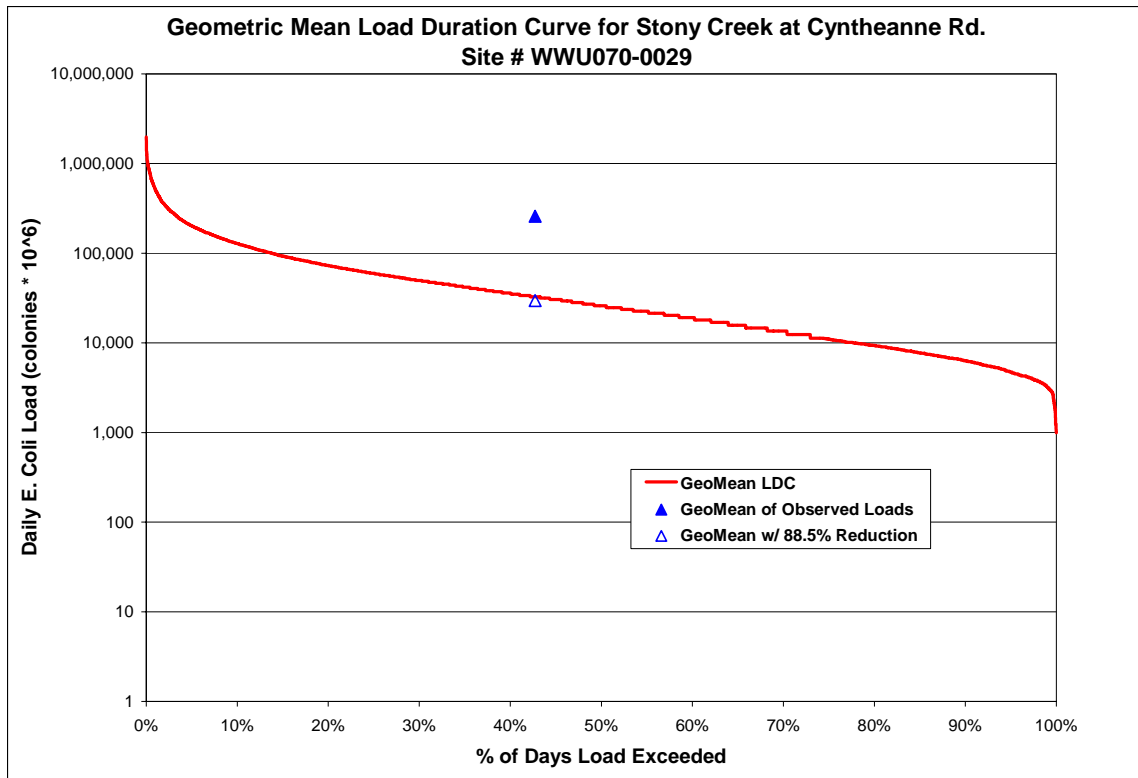


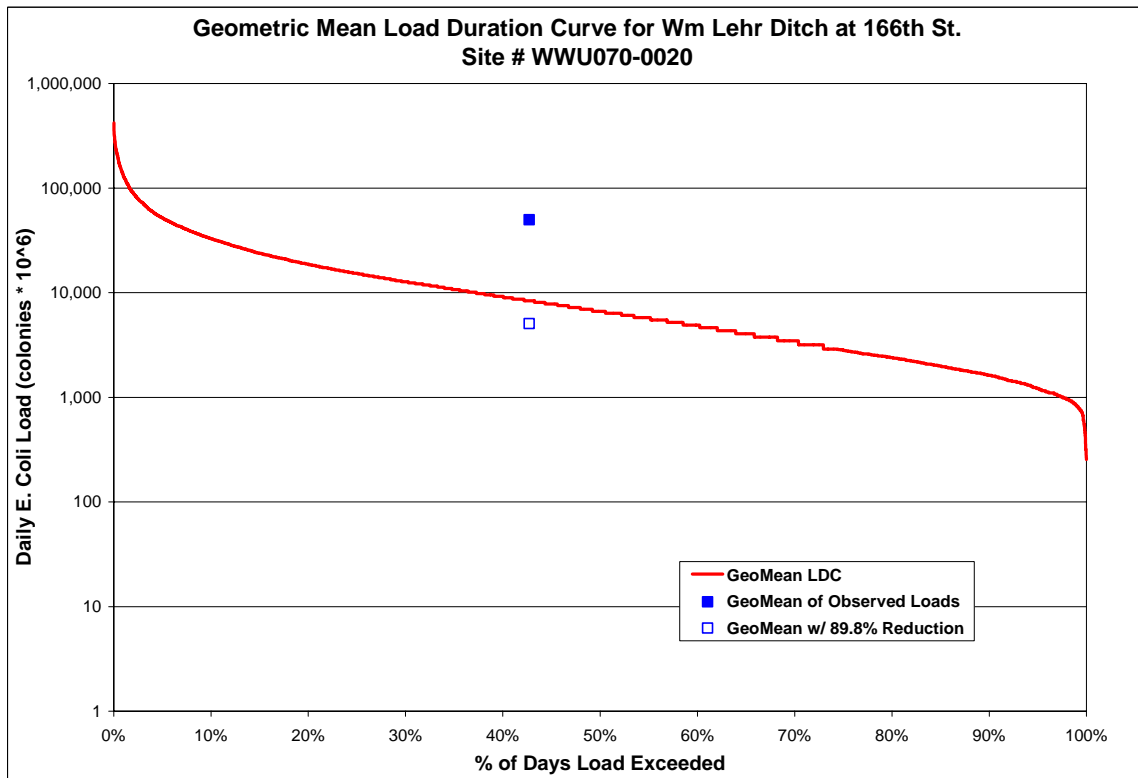
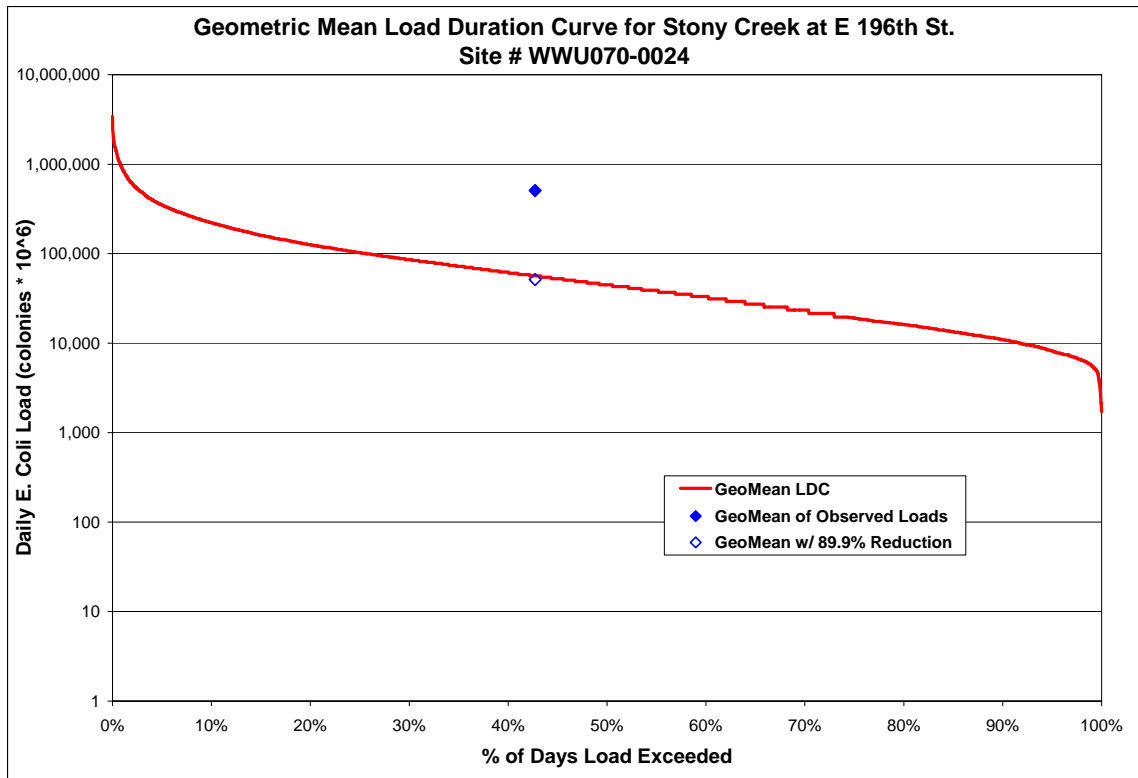


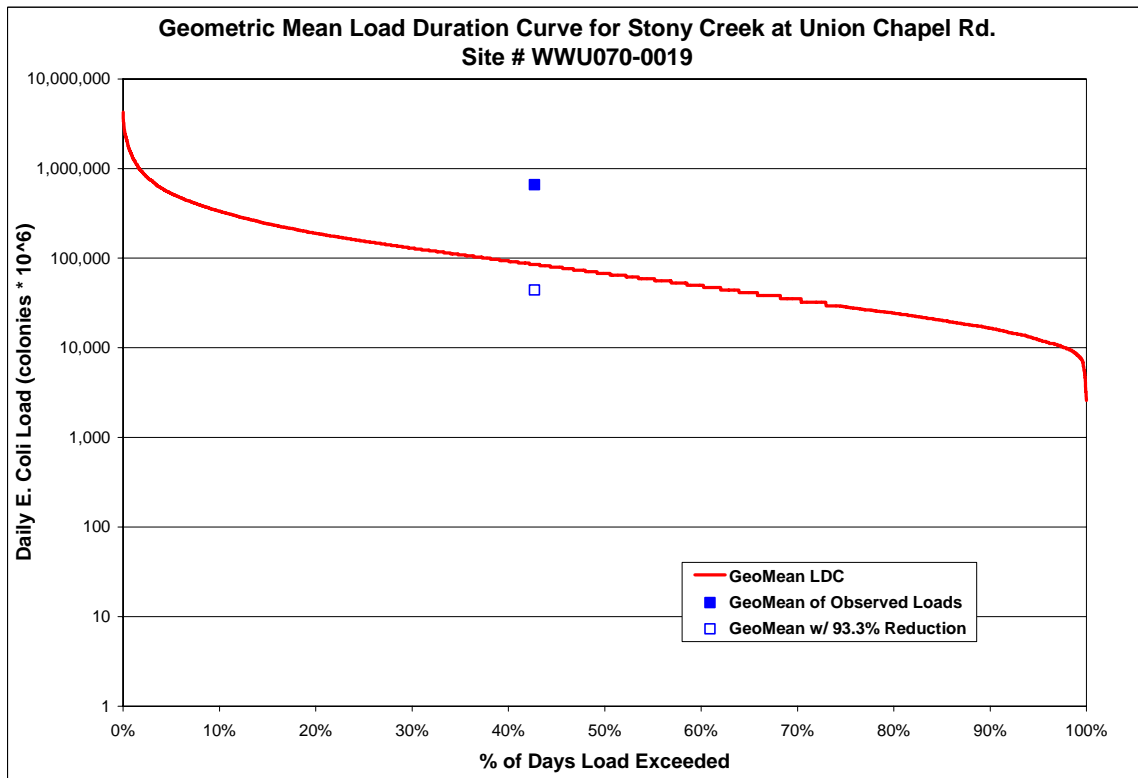
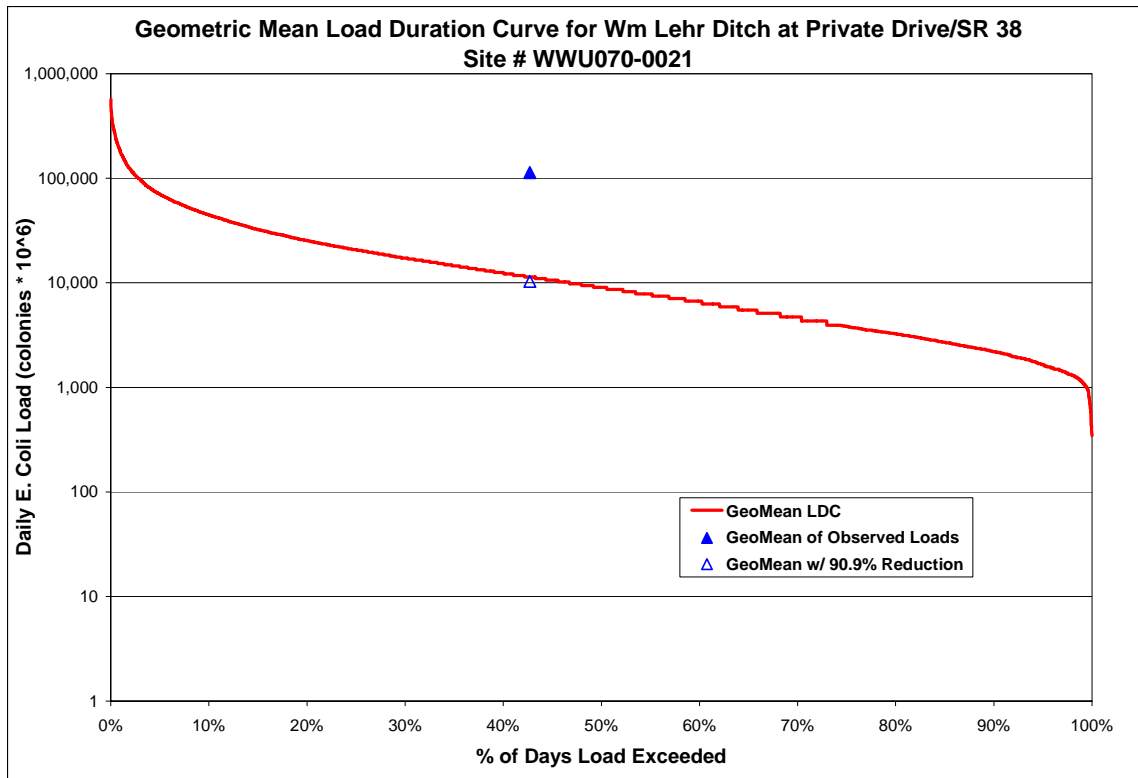


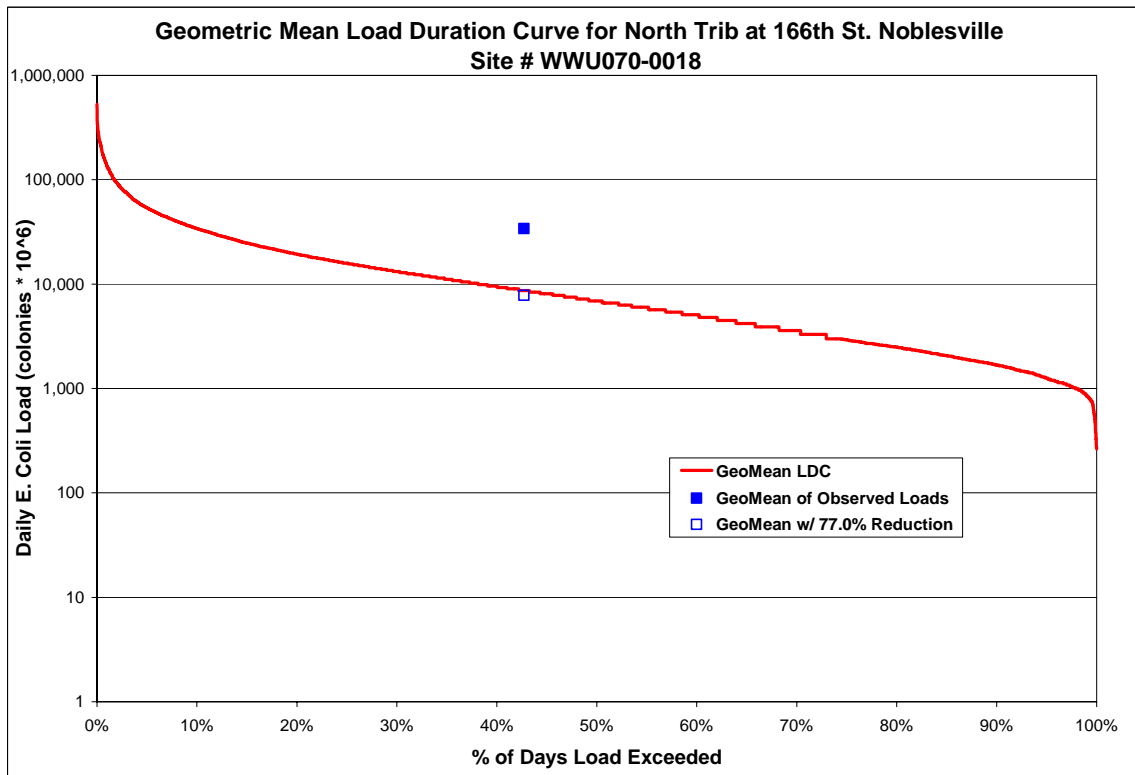
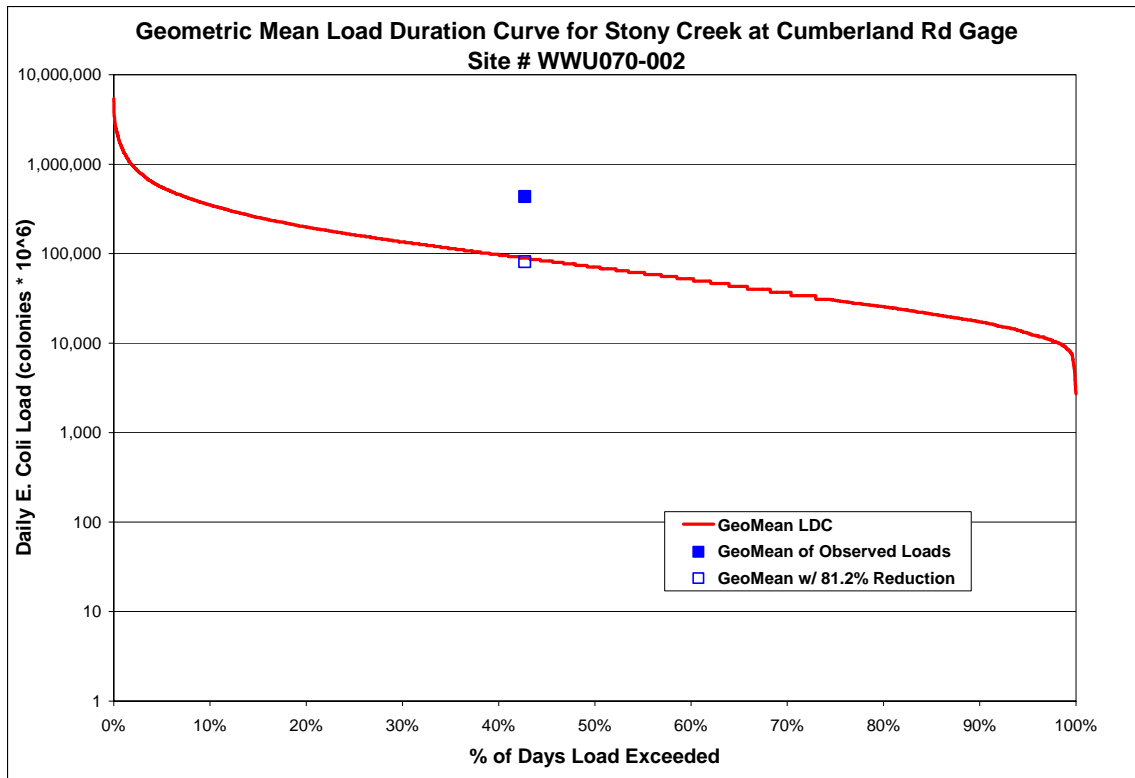
Geometric Mean Load Duration Curves for Stony Creek Watershed

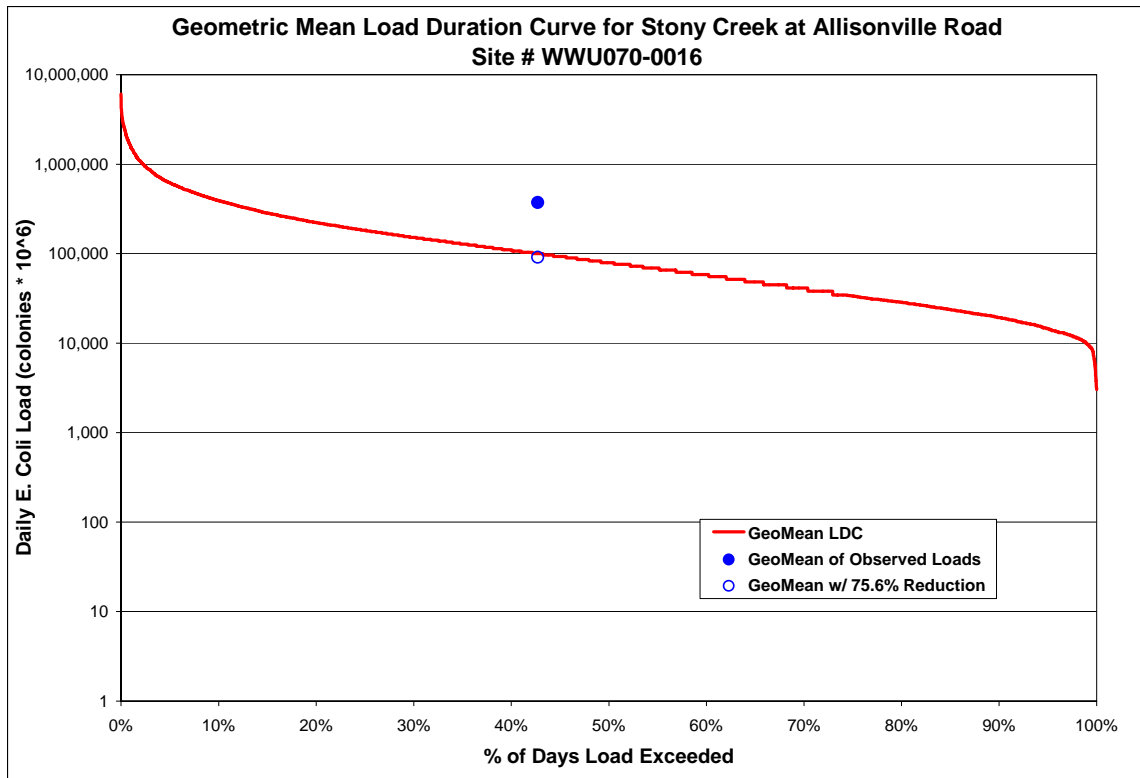












Attachment F - Load Reductions

Monitoring Location	Required Reduction
Killbuck Creek	
Mud Creek	34.86%
Killbuck Creek Headwaters	98.49%
SR 28/US 35	93.81%
CR 700W	78.66%
CR 750W	94.84%
CR 925W	83.04%
SR 332	94.84%
CR 425 E	94.84%
CR 400 N	93.81%
Little Killbuck Creek	98.57%
ST 9 Bridge	83.92%
Broadway Street	79.71%
Pipe Creek	
CR 600 W	94.88%
CR 900 N	93.85%
CR 1400 N	88.94%
CR 1100 N	92.03%
R 200 W	98.97%
CR 500 W	99.12%
SR 128	94.22%
SR 13	92.03%
Duck Creek	
CR 1400N	72.49%
Todd Ditch	76.19%
CR 1300 N	63.35%
S 9th Stree	98.76%
Elwood WWTP	98.65%
CR 1050 N	96.82%
Highway 28	92.71%
CR 900 W	97.18%
CR 1000 N	95.73%
Polywag Creek	92.26%
CR 900 N	92.71%
Hayworth Road	90.47%
Bear Creek	96.24%
Lamberson Ditch	97.74%
SR 213	90.47%
Stony Creek	
CR 650 W	78.66%
CR 825 W	87.37%
CR 925 W	94.84%
SR 132/13	94.84%
CR 1000 W	94.84%
Cyntheanne Rd	92.71%
70-0026	91.15%
Wm Lock E 206th/Durbin Rd	94.84%
Wm Lock Ditch at E 196th St	90.47%
E 196th Street	93.81%
Wm Lehr Ditch at 166th St	93.81%
Wm Lehr at SR 38	93.81%
SR 38	93.81%
Union Chapel Rd	94.84%
Cumberland Rd	84.90%
N Trib at 166th	86.54%
Allisonville Rd	83.92%

Appendix G

The incremental watershed LDC approach can be partitioned into six major steps:

- (1) **Subwatershed segmentation**, which is a GIS-based procedure used to identify the incremental drainage areas contributing to each sampling location in a watershed.
- (2) **Determination of flow duration curves (QDCs)** for each sampling location. Since most sampling locations do not have a flow gage, flows (and QDCs) are estimated for the ungaged locations using watershed information such as the incremental drainage areas to each location, the land uses, and soil hydrologic groups within each incremental subwatershed, and known management practices applied to specific land parcels.
- (3) **Calculation of allowable load duration curves (LDCs)** for each location. Two *E.coli* LDCs are established for each location: a single sample LDC and a geometric mean LDC. Each of these LDCs is the simple product of the QDC and the appropriate water quality standard.
- (4) **Determination of Required Reductions** at each sampling location. These initial reductions are based on the difference between the highest observed concentration at each location and the single sample water quality standard.
- (5) **Estimation of Existing Source Category Loads.** The total potential conservative *E.coli* loads associated with each source category are determined, within each subwatershed, via the methods described in chapter 4. These subwatershed estimates are then adjusted to match the median-flow, high-concentration load observed at each sampling location.
- (6) **Determination of Source Category Percent Reductions** within each subwatershed. Individual percent reductions for each source category contributing to the subwatershed loads are incremented until loading targets associated with both the single sample and geometric mean water quality standards are achieved for all subwatersheds.

The remainder of this chapter provides more detail on each of the above steps. For illustration purposes, the steps are described for the Pipe Creek TMDL. Equivalent tables and figures for the Duck Creek, Killbuck Creek, and Stony Creek TMDLs are included in Appendix C.

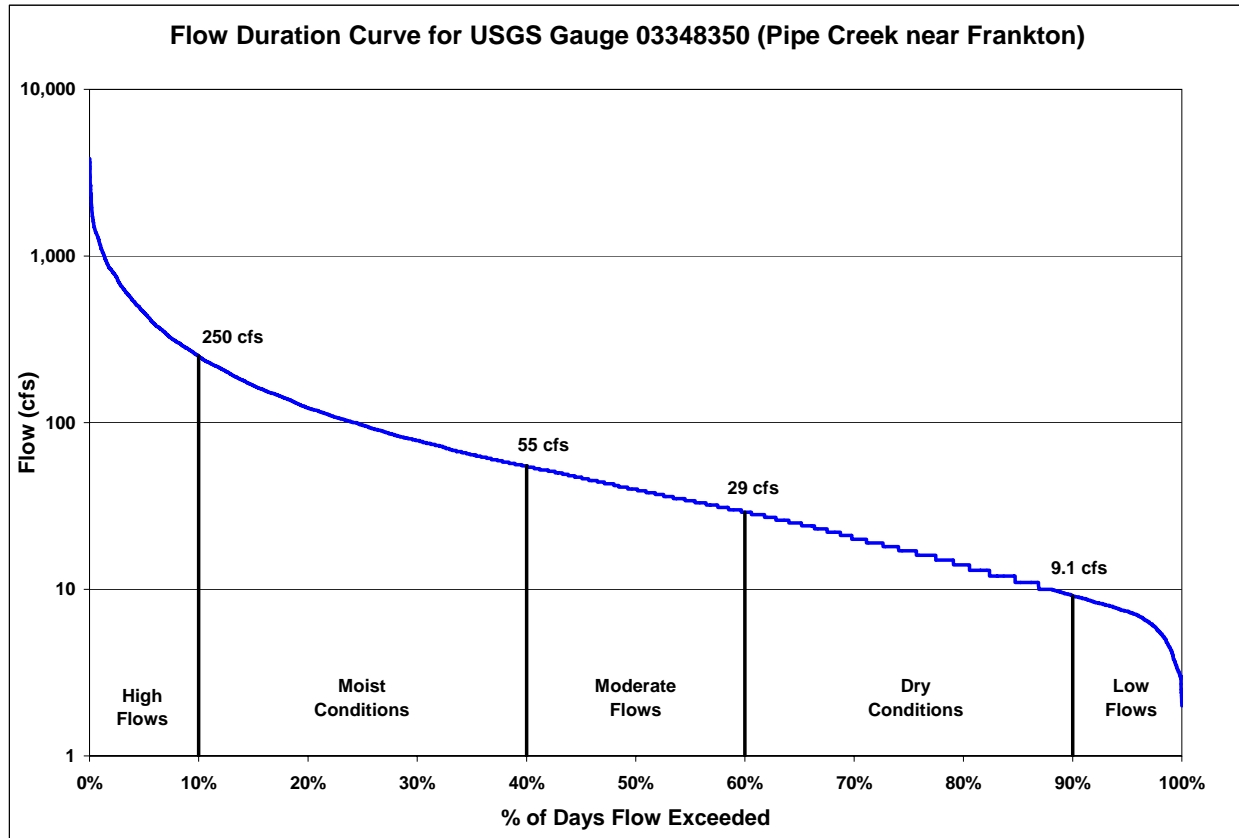


Figure 5-1. Flow Duration Curve for Pipe Creek Gage (5/1968 – 9/2003)

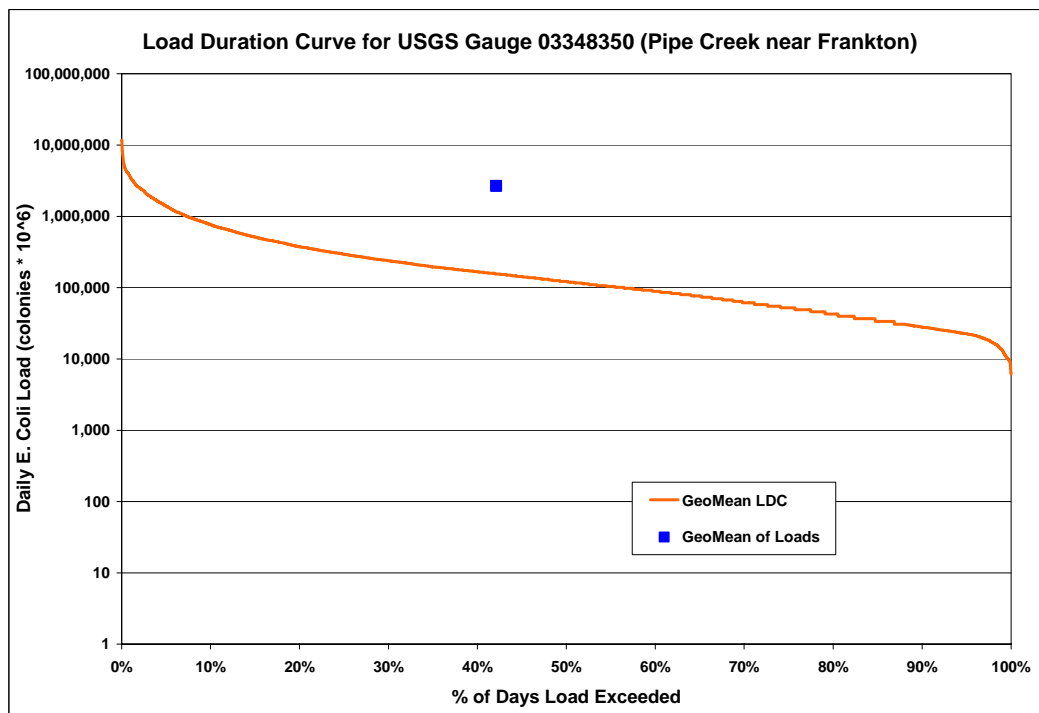


Figure 5-2. Geometric Mean Load Duration Curve for Pipe Creek Gage (5/1968 – 9/2003)

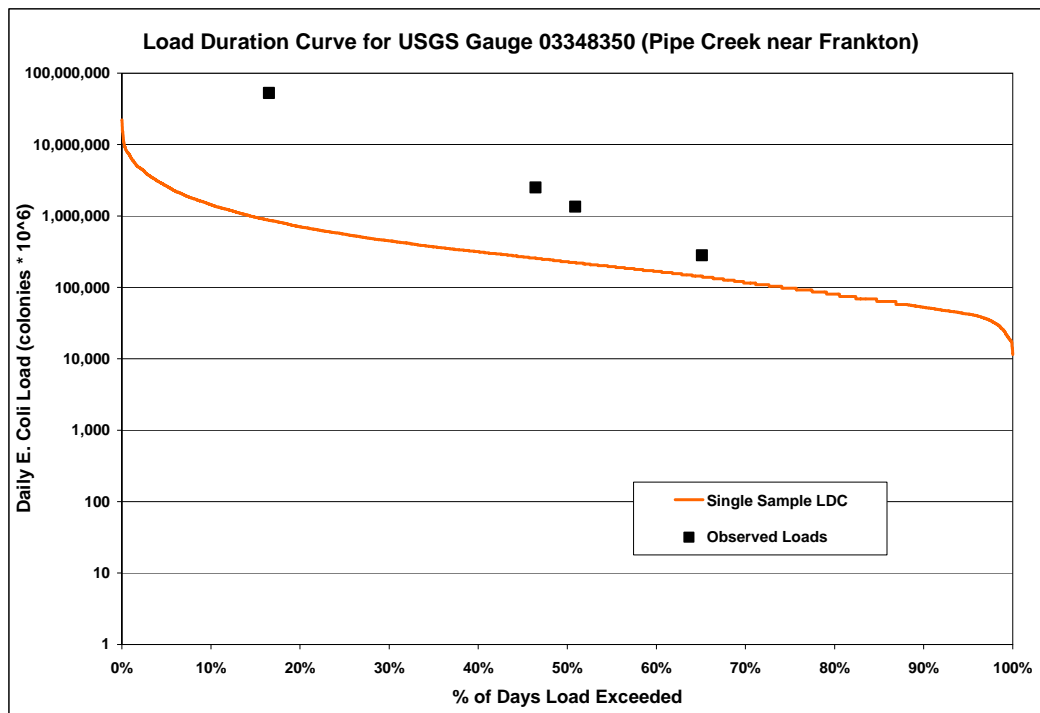


Figure 5-3. Single Sample Load Duration Curve for Pipe Creek Gage (5/1968 – 9/2003)

5.1 SUBWATERSHED SEGMENTATION

The first step in the incremental watershed LDC approach is to establish accurate subwatershed boundaries that correspond to the sampling locations within the watershed. Care must be taken to ensure that the subwatershed boundaries are hydrologically consistent with known stream networks and topographical elevation data. As discussed in Section 2, the SRTM elevation data was used as the basis for delineating the subwatershed boundaries. Stream features from the NHD 1:100,000-scale hydrography network (with additional reaches extracted from digital raster graphic quad maps) were etched into the SRTM grids, using digital integration techniques developed by Saunders (2000) and Hellweger (1997). The resultant Pipe Creek subwatershed delineations are shown in Figure 5-4. Each subwatershed is denoted by the Station ID of the sampling location at its outlet. Subwatersheds are classified as either “headwater” or “incremental” subwatersheds, based on whether the specific subwatershed receives any upstream flow. The Pipe Creek watersheds also include an “unmonitored” subwatershed, which defines an area within the drainage area to the impaired water that is also downstream of all sampling locations. Table 5-1 shows the acreages associated with each subwatershed. As with the figure 5-4, headwater subwatersheds are marked in yellow.

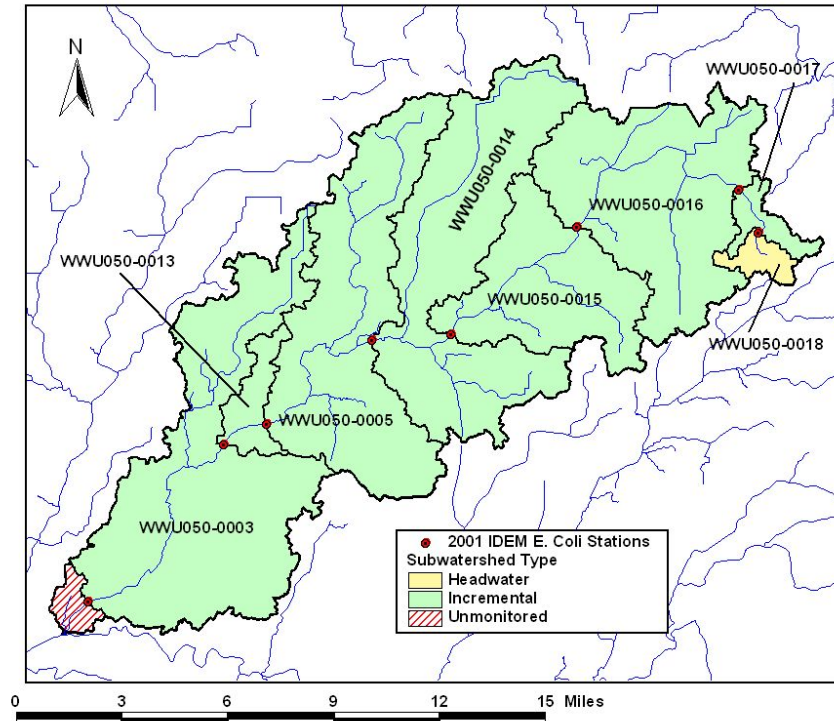


Figure 5-4. Subwatersheds Delineated for the Pipe Creek Watershed

Table 5-1. Subwatershed Statistics for the Pipe Creek Watershed

Pipe Creek Monitoring Location	Station ID	Subwatershed Area (acres)	Cumulative Area (acres)	Cumulative Drainage Area Ratio to USGS Gage*	Drainage Area Ratio Median Flow (cfs)
CR 600W	WWU050-0018	1,208	1,208	0.017	0.68
CR 900N	WWU050-0017	1,546	2,754	0.038	1.54
CR 1400N	WWU050-0016	17,747	20,501	0.287	11.46
CR 1100N	WWU050-0015	11,297	31,798	0.444	17.78
CR 200W	WWU050-0014	20,127	51,925	0.726	29.03
CR 500W	WWU050-0005	19,620	71,544	1.000	40.00
SR 128	WWU050-0013	2,291	73,835	1.032	41.28
SR13	WWU050-0003	24,651	98,486	1.377	55.06
Unmonitored	-----	1,019	99,504	1.391	55.63

*compared to USGS gage 03348350 (Pipe Creek near Frankton)

5.2 **ESTABLISHMENT OF QDCS AND DETERMINATION OF ALLOWABLE LDCS**

In order to apply the LDC methodology to every monitoring location in the watersheds, flow information must be derived for each location. USGS gaged flows within the watersheds are used as the basis to determine flows at the other locations. In the Pipe Creek watershed, USGS gage 03348350 is located at County Road 500W. In the Stony Creek watershed, USGS gage 03350700 is located in Noblesville at Allisonville Road. In the Killbuck Creek watershed, the currently inactive USGS gage 03348020 was located near Gaston just upstream of County Road 700W. No USGS gage or flow history exists for Duck Creek, so the gage from the adjacent Pipe Creek watershed was used as a surrogate. Drainage area ratios for all monitoring locations in the watersheds were established by dividing the cumulative watershed

area for the location by the cumulative watershed area at the USGS gage. Table 5-1 shows the drainage area ratios and median flows for each Pipe Creek monitoring location.

Using the drainage area ratios and the QDC for each USGS gage location, an initial set of QDCs for the other watershed monitoring locations can be created by multiplying each location's drainage area ratio by the USGS gage QDC. The QDCs were further adjusted by considering the land uses, soil type hydrologic groups, and the row crop tile drainage locations in each subwatershed. These GIS layers are shown in Section 2. Using the intersection of these GIS distributions, the Soil Conservation Service (SCS) Curve Number (CN) methodology (USDA-SCS, 1973) was applied to establish estimated CNs for each intersected parcel. Table 5-2 shows the CNs assigned to each parcel of a specific land use/hydrologic group combination. For row crop land uses that also have a drainage classification of "somewhat poorly drained", "poorly drained", or "very poorly drained", tile drainage was assumed to have been implemented, thereby reducing the CN by an additional 10 units (i.e. 10%).

Using GIS, a "composite curve number" for the total area draining to a USGS gage was determined. This composite CN is calculated within the GIS by determining the percentage of each land use/hydrologic group/row crop drainage combination occurring within the drainage area, multiplying the individual percentages by the CN associated with each combination, and then summing the resultant products. This process is illustrated for USGS gage 03348350 at Pipe Creek in Table 5-3. The composite CN for that gage is 79.19.

The same approach for determining composite curve numbers is then followed for each subwatershed in the study area. As an example of this process, Tables 5-4, 5-5, and 5-6 show the respective areas, percentages of subwatershed areas, and incremental curve numbers, for each land use/hydrologic group/tile drainage combination in the Pipe Creek subwatersheds. Table 5-6 also shows the composite curve number for each Pipe Creek subwatershed, as well as a calculated "Composite Curve Number ratio" of the subwatershed composite curve number to the USGS gage composite curve number. This composite CN ratio is used as a multiplicative factor and applied to the incremental flows for each subwatershed. Figure 5-5 shows the resultant QDCs for all monitoring locations within the Pipe Creek watershed. Table 5-7 shows the CN-adjusted median flows associated with each QDC.

As can be seen from the Table 5-7, the adjustments to the QDC profiles are relatively insignificant. This is partly due to the magnitudes the SCS Curve Numbers specified for each category and also due to the relatively minor differences specified for tile drainage management practices on agricultural row crops. Other management practices may also affect the QDC profile, but additional flow adjustments will probably remain minor in comparison to the drainage area ratio factor.

Table 5-2. SCS Curve Numbers Assigned to Land Use/Hydrologic Group/Tile Drainage Categories

NLCD Land Use Category	Hydrologic Soil Group		
	B	C	D
Open Water	100	100	100
Low Intensity Residential	68	79	84
High Intensity Residential	85	90	92
Commercial/Industrial/Transportation	90	92	94
Deciduous Forest	55	70	77
Evergreen Forest	55	70	77
Mixed Forest	55	70	77
Pasture/Hay	61	74	80
Row Crops - no conservation treatment	81	88	91
Row Crops - tile drainage	71	78	81
Urban/Recreational/Grasses	65	77	82
Woody Wetlands	95	95	95
Emergent Herbaceous Wetlands	95	95	95

(Source, USDA-SCS (1973))

Table 5-3. Composite Curve Number Process for Pipe Creek Gage Drainage Area

NLCD Land Use (MRLC) and NRCS Soil Hydrologic Group (Statsgo)	Pipe Creek Gage		SCS CN	Composite CN
	Area (acres)	Percent		
Open Water - B,C,D	172	0.24%	100	0.24
Low Intensity Residential - B	805	1.12%	68	0.76
Low Intensity Residential - C	953	1.33%	79	1.05
Low Intensity Residential - D	0	0.00%	84	0.00
High Intensity Residential - B	78	0.11%	85	0.09
High Intensity Residential - C	36	0.05%	90	0.05
High Intensity Residential - D	0	0.00%	92	0.00
Commercial/Industrial/Transportation - B	249	0.35%	90	0.31
Commercial/Industrial/Transportation - C	114	0.16%	92	0.15
Commercial/Industrial/Transportation - D	0	0.00%	94	0.00
Deciduous Forest - B	733	1.02%	55	0.56
Deciduous Forest - C	1,416	1.98%	70	1.39
Deciduous Forest - D	0	0.00%	77	0.00
Evergreen Forest - B	1	0.00%	55	0.00
Evergreen Forest - C	1	0.00%	70	0.00
Evergreen Forest - D	0	0.00%	77	0.00
Mixed Forest - B	0.4	0.00%	55	0.00
Mixed Forest - C	0.2	0.00%	70	0.00
Mixed Forest - D	0	0.00%	77	0.00
Pasture/Hay - B	1,923	2.69%	61	1.64
Pasture/Hay - C	6,369	8.90%	74	6.59
Pasture/Hay - D	0	0.00%	80	0.00
Row Crops - B, no tile drainage	4,278	5.98%	81	4.84
Row Crops - B, tile drained	0	0.00%	71	0.00
Row Crops - C, no tile drainage	13,937	19.48%	88	17.14
Row Crops - C, tile drained	38,479	53.78%	78	41.95
Urban/Recreational/Grasses - B	206	0.29%	65	0.19
Urban/Recreational/Grasses - C	579	0.81%	77	0.62
Urban/Recreational/Grasses - D	0	0.00%	82	0.00
Woody Wetlands - B,C,D	1,155	1.61%	95	1.53
Emergent Herbaceous Wetlands - B,C,D	59	0.08%	95	0.08
Totals	71,544	100.0%		79.19

Table 5-4. Pipe Creek Subwatershed Land Use/Hydrologic Group/Tile Drainage Areas

NLCD Land Use (MRLC) and NRCS Soil Hydrologic Group (Statsgo)	CR-600W acres	CR-900N acres	CR-1400N acres	CR-1100N acres	CR-200W acres	CR-500W acres	SR-128 acres	SR-13 acres	Ungaged acres
Open Water - B,C,D	0.2	0.2	46	10.1	38	77	-----	19.7	0.7
Low Intensity Residential - B	-----	-----	-----	176	556	72	235	105	8.3
Low Intensity Residential - C	-----	143	5.9	180	542	82	77	70	-----
Low Intensity Residential - D	-----	-----	-----	-----	-----	-----	-----	-----	-----
High Intensity Residential - B	-----	-----	-----	6.2	61	11.0	14.7	0.6	-----
High Intensity Residential - C	-----	2.6	0.2	6.9	20	6.5	0.3	1.4	-----
High Intensity Residential - D	-----	-----	-----	-----	-----	-----	-----	-----	-----
Commercial/Industrial/Transportation - B	-----	-----	-----	13.4	222	14.0	51	-----	-----
Commercial/Industrial/Transportation - C	-----	24	28	18.6	36	7.2	-----	18.0	-----
Commercial/Industrial/Transportation - D	-----	-----	-----	-----	-----	-----	-----	-----	-----
Deciduous Forest - B	-----	-----	-----	6.5	179	548	55	437	28
Deciduous Forest - C	46	34	273	455	421	187	0.8	155	3.5
Deciduous Forest - D	-----	-----	-----	-----	-----	-----	-----	-----	-----
Evergreen Forest - B	-----	-----	-----	-----	0.7	0.2	0.8	0.2	-----
Evergreen Forest - C	-----	-----	0.2	0.4	0.4	-----	-----	-----	-----
Evergreen Forest - D	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mixed Forest - B	-----	-----	-----	-----	0.1	0.2	0.2	0.2	-----
Mixed Forest - C	-----	-----	-----	0.2	-----	-----	-----	-----	-----
Mixed Forest - D	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pasture/Hay - B	-----	-----	-----	18.5	464	1441	178	1233	86
Pasture/Hay - C	73	65	1131	1631	2152	1317	41	1848	0.3
Pasture/Hay - D	-----	-----	-----	-----	-----	-----	-----	-----	-----
Row Crops - B, no tile drainage	-----	-----	-----	59	688	3531	754	3633	481
Row Crops - B, tile drained	-----	-----	-----	-----	-----	-----	-----	-----	-----
Row Crops - C, no tile drainage	213	263	2584	3172	5434	2271	72	1689	35
Row Crops - C, tile drained	859	973	13486	5198	8167	9797	604	15124	328
Urban/Recreational/Grasses - B	-----	-----	-----	20	162	24	176	50	-----
Urban/Recreational/Grasses - C	-----	18.3	-----	66	489	5.3	17.0	24	-----
Urban/Recreational/Grasses - D	-----	-----	-----	-----	-----	-----	-----	-----	-----
Woody Wetlands - B,C,D	15.4	15.0	174	254	471	225	13.8	241	47
Emergent Herbaceous Wetlands - B,C,D	2.4	7.8	17.2	5.3	24	3.1	0.4	2.2	-----
Totals	1208	1546	17747	11297	20126	19620	2291	24651	1019

Table 5-5. Pipe Creek Subwatershed Land Use/Hydrologic Group/Tile Drainage Area Percentages

[illegible]

Table 5-6. Pipe Creek Subwatershed Incremental Composite Curve Numbers

NLCD Land Use Category (MRLC Classifications)	CR-600W Comp CN	CR-900N Comp CN	CR-1400N Comp CN	CR-1100N Comp CN	CR-200W Comp CN	CR-500W Comp CN	SR-128 Comp CN	SR-13 Comp CN	Ungaged Comp CN
Open Water - B,C,D	0.01	0.01	0.26	0.09	0.19	0.39	-----	0.08	0.06
Low Intensity Residential - B	-----	-----	-----	1.06	1.88	0.25	6.97	0.29	0.56
Low Intensity Residential - C	-----	7.33	0.03	1.26	2.13	0.33	2.67	0.23	-----
Low Intensity Residential - D	-----	-----	-----	-----	-----	-----	-----	-----	-----
High Intensity Residential - B	-----	-----	-----	0.05	0.26	0.05	0.55	0.002	-----
High Intensity Residential - C	-----	0.15	0.001	0.05	0.09	0.03	0.01	0.01	-----
High Intensity Residential - D	-----	-----	-----	-----	-----	-----	-----	-----	-----
Commercial/Industrial/Transportation - B	-----	-----	-----	0.11	0.99	0.06	1.99	-----	-----
Commercial/Industrial/Transportation - C	-----	1.41	0.15	0.15	0.17	0.03	-----	0.07	-----
Commercial/Industrial/Transportation - D	-----	-----	-----	-----	-----	-----	-----	-----	-----
Deciduous Forest - B	-----	-----	-----	0.03	0.49	1.54	1.33	0.98	1.52
Deciduous Forest - C	2.65	1.55	1.08	2.82	1.46	0.67	0.03	0.44	0.24
Deciduous Forest - D	-----	-----	-----	-----	-----	-----	-----	-----	-----
Evergreen Forest - B	-----	-----	-----	-----	0.002	0.001	0.02	0.0005	-----
Evergreen Forest - C	-----	-----	0.001	0.002	0.002	-----	-----	-----	-----
Evergreen Forest - D	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mixed Forest - B	-----	-----	-----	-----	0.0004	0.001	0.01	0.0005	-----
Mixed Forest - C	-----	-----	-----	0.001	-----	-----	-----	-----	-----
Mixed Forest - D	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pasture/Hay - B	-----	-----	-----	0.10	1.41	4.48	4.73	3.05	5.18
Pasture/Hay - C	4.47	3.10	4.71	10.68	7.91	4.97	1.32	5.55	0.02
Pasture/Hay - D	-----	-----	-----	-----	-----	-----	-----	-----	-----
Row Crops - B, no tile drainage	-----	-----	-----	0.42	2.77	14.58	26.67	11.94	38.26
Row Crops - B, tile drained	-----	-----	-----	-----	-----	-----	-----	-----	-----
Row Crops - C, no tile drainage	15.51	14.95	12.81	24.71	23.76	10.18	2.76	6.03	3.03
Row Crops - C, tile drained	55.44	49.11	59.27	35.89	31.65	38.95	20.55	47.85	25.12
Urban/Recreational/Grasses - B	-----	-----	-----	0.12	0.52	0.08	5.00	0.13	-----
Urban/Recreational/Grasses - C	-----	0.91	-----	0.45	1.87	0.02	0.57	0.07	-----
Urban/Recreational/Grasses - D	-----	-----	-----	-----	-----	-----	-----	-----	-----
Woody Wetlands - B,C,D	1.21	0.92	0.93	2.14	2.22	1.09	0.57	0.93	4.37
Emergent Herbaceous Wetlands - B,C,D	0.19	0.48	0.09	0.04	0.11	0.01	0.02	0.01	-----
Composite Curve Numbers	79.47	79.92	79.34	80.17	79.88	77.72	75.76	77.65	78.37
Composite CN Ratio to USGS Gage	1.0035	1.0092	1.0019	1.0123	1.0087	0.9814	0.9567	0.9805	0.9896

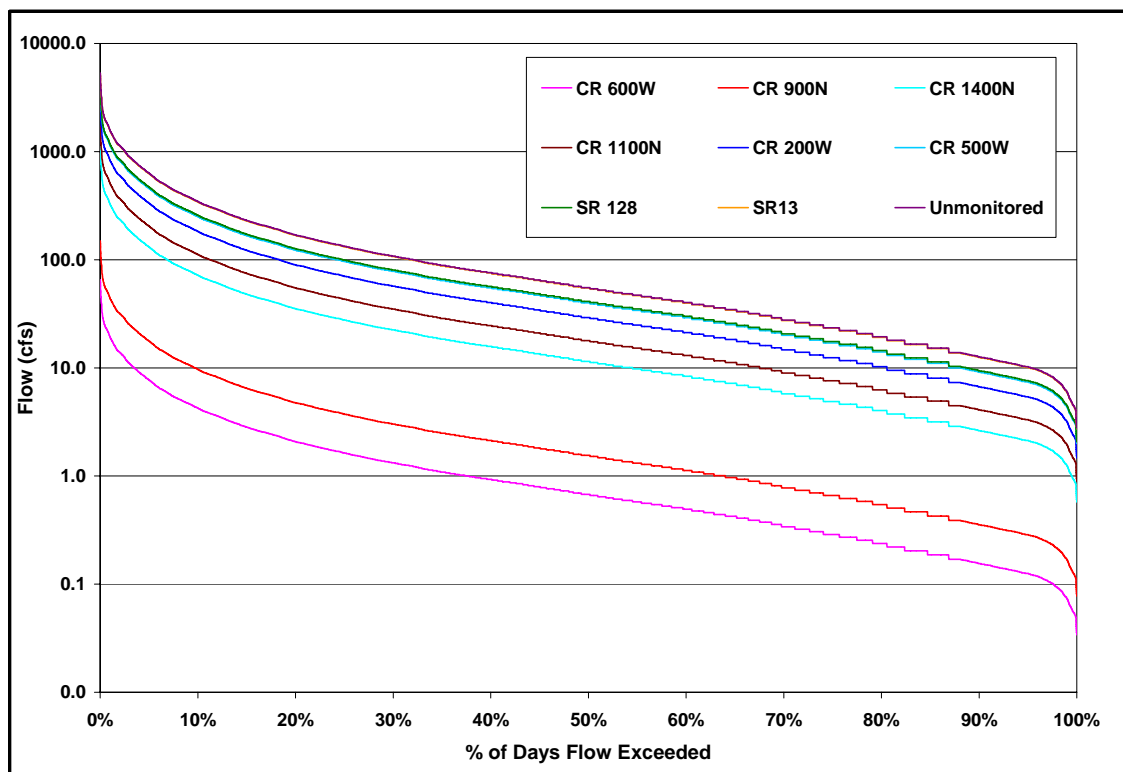


Figure 5-5. Flow Duration Curves for Pipe Creek Sampling Stations

Table 5-7. Pipe Creek Composite Curve Number Adjustments and Adjusted Median QDC Flows

Pipe Creek Monitoring Location	Station ID	Cumulative Drainage Area Ratio to USGS Gage*	Drainage Area Ratio Median Flow (cfs)	Composite CN Ratio	Adjusted Median QDC Flow (cfs)
CR 600W	WWU050-0018	0.017	0.68	1.0035	0.68
CR 900N	WWU050-0017	0.038	1.54	1.0092	1.55
CR 1400N	WWU050-0016	0.287	11.46	1.0019	11.49
CR 1100N	WWU050-0015	0.444	17.78	1.0124	17.89
CR 200W	WWU050-0014	0.726	29.03	1.0087	29.24
CR 500W	WWU050-0005	1.000	40.00	0.9814	40.00
SR 128	WWU050-0013	1.032	41.28	0.9567	41.23
SR13	WWU050-0003	1.377	55.06	0.9805	54.74
Unmonitored	-----	1.391	55.63	0.9896	55.30

*compared to USGS gage 03348350 (Pipe Creek near Frankton)

5.3 CALCULATION OF ALLOWABLE LOAD DURATION CURVES

Once the QDCs for each monitoring location are established, duration curves for the allowable *E. coli* loads are easily calculated by multiplying the QDC by the appropriate water quality criterion. Individual single sample LDC plots for all monitoring locations within the watersheds are included in Appendix D. These LDCs represent the product of

the individual QDCs and the single sample standard of 235 colonies / 100 mL. Geometric mean LDC plots for monitoring locations that have the appropriate number and frequency of samples collected are included in Appendix E. The geometric mean LDCs represent the product of the QDCs and the geometric mean standard of 125 colonies / 100 mL.

Figures 5-6 and 5-7 show the respective single sample and geometric mean LDCs for station WWU0050-0003, located on Pipe Creek at SR 13. In figure 5-6, the E.coli loads associated with each sample are also plotted at the percentile of the flow that was recorded for the same day as the measurement. As can be seen from figure 5-6, all sampled E.coli loads for this station fall above the LDC. The blue line on the plot shows the loading distribution associated with the highest concentration measurement at the station. The difference between this line and the LDC is the percent reduction required in order to meet the single sample standard. As can be seen from the logarithmic plot, the high concentration line is almost a factor of ten times greater than the single sample standard line, indicating a required reduction of almost 90%.

Figure 5-7 shows that the geometric mean load of the five single sample measurements also falls above the geometric mean LDC. Frequently, the loading reduction implemented to meet the single sample standard will resolve this situation. However, when the variance of the single sample measurements is small, the geometric mean of the reduced single sample concentrations may still exceed the geometric mean standard. When this is the case, additional loading reductions, over and above those required to meet the single sample standard, are also required.

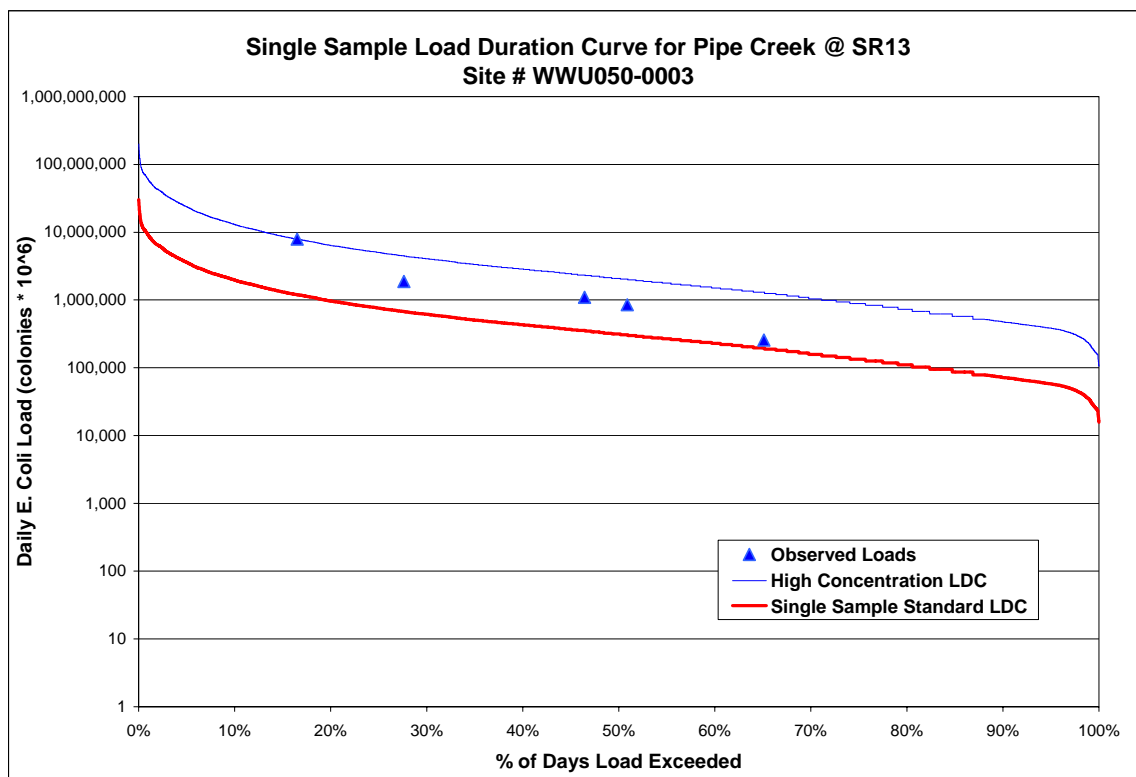


Figure 5-6. Single Sample Load Duration Curve for Pipe Creek at SR13.

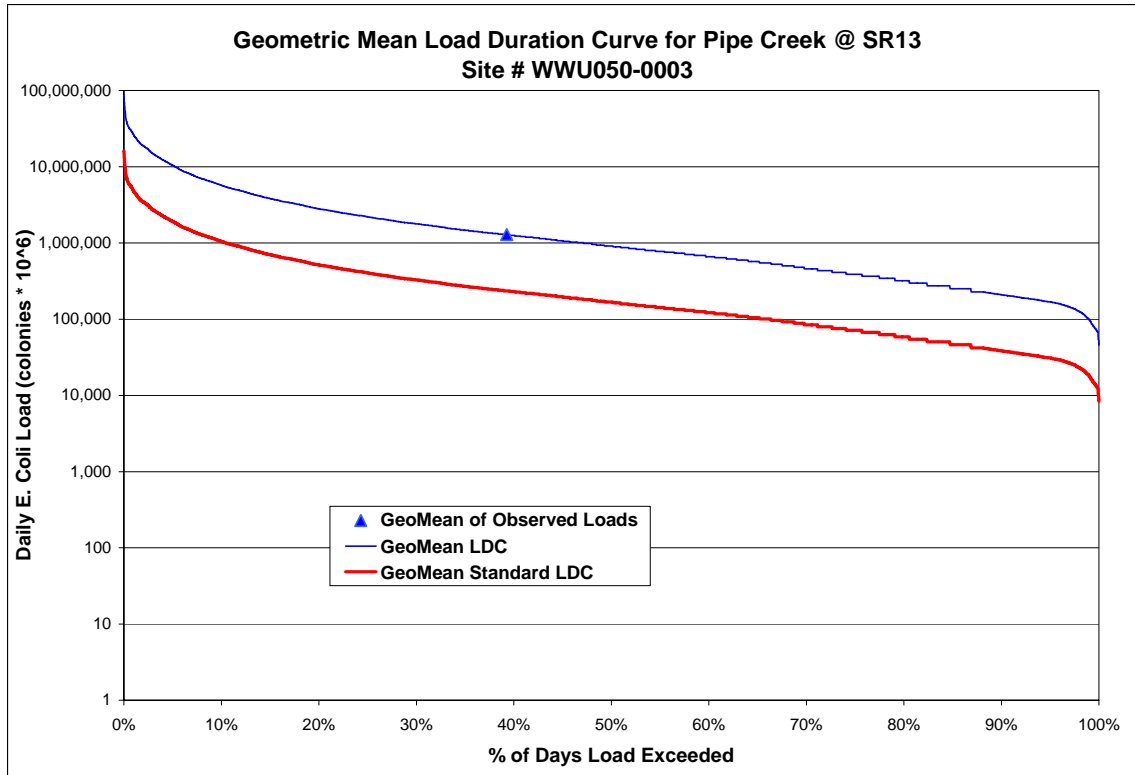


Figure 5-7. Geometric Mean Load Duration Curve for Pipe Creek at SR13.

5.4 **DETERMINATION OF REQUIRED REDUCTIONS**

Once adjusted QDCs and allowable LDCs have been established for each subwatershed, the required load reductions within each subwatershed are determined. In Indiana, state water quality regulations do not allow for any percentile exceedances of the two *E. coli* standards. Since this is the case, the highest observed *E. coli* concentration at any monitoring location defines the magnitude of the required reduction at that location (e.g. if the highest observed *E. coli* concentration at a sampling location was 470 colonies / 100 mL, then the required reduction would be 50%). Additional reductions would be required if the geometric mean of the resultant concentration reductions was still above 125 colonies / 100 mL.

By taking the product of the highest observed *E. coli* concentration and the adjusted median QDC value for each monitoring location, the median *E. coli* load at the concentration is determined. The maximum allowable median load at each location is determined as 90% of the *E. coli* single sample standard multiplied by the adjusted median QDC value. This accounts for margin-of-safety. The maximum allowable incremental median load can then be calculated for each subwatershed by subtracting the total loads from all upstream subwatersheds. Table 5-8 shows (a) the highest observed *E. coli* concentrations, (b) the required percent reductions, (c) the median observed *E. coli* loads, (d) the maximum allowable median *E. coli* loads, and (e) the maximum allowable incremental median *E. coli* loads, for each subwatershed in the Pipe Creek watersheds. A second iteration of this process to calculate the maximum allowable median load is executed when the load reductions result in a geometric mean of estimated concentrations that still exceeds the geometric mean standard.

Table 5-8. Pipe Creek Required Reductions and Allowable Median Loads

Pipe Creek Monitoring Location	Station ID	Max E. Coli Concentration (col / 100 mL)	Sample Date	Adjusted Median QDC Flow (cfs)	Median E. Coli Load (col / day)	Allowable Median Load (col / day)	Required % Reduction	Allowable Incremental Median Load (col / day)
CR 600W	WWU050-0018	2,419	19-Jun-01	0.68	4.01E+10	3.51E+09	91.3%	3.51E+09
CR 900N	WWU050-0017	2,014	26-Jun-01	1.55	7.64E+10	8.03E+09	89.5%	4.52E+09
CR 1400N	WWU050-0016	1,120	03-Jul-01	11.5	3.15E+11	5.16E+10	83.6%	4.36E+10
CR 1100N	WWU050-0015	1,553	12-Jun-01	17.9	6.80E+11	9.26E+10	86.4%	4.10E+10
CR 200W	WWU050-0014	12,033	12-Jun-01	29.2	8.61E+12	1.51E+11	98.2%	5.88E+10
CR 500W	WWU050-0005	14,136	12-Jun-01	40.0	1.38E+13	2.07E+11	98.5%	5.57E+10
SR 128	WWU050-0013	2,142	19-Jun-01	41.2	2.16E+12	2.13E+11	90.1%	6.34E+09
SR13	WWU050-0003	1,553	12-Jun-01	54.7	2.08E+12	2.83E+11	86.4%	7.00E+10
Unmonitored	-----	-----	-----	55.3	-----	2.86E+11	-----	2.92E+09

5.5 ESTIMATION OF SOURCE CATEGORY LOADS

Source category loads within each subwatershed are initially calculated via the procedures outlined in Section 4. As discussed, those estimates represent the “total potential conservative loads” of *E. coli* and do not generally account for loading losses due to containment or decay. In order to adjust the estimated loads down to the observed median values, two factors are employed for each subwatershed. The downstream decay factor is calculated based on the distance that pollutant loads must travel from a subwatershed outlet point downstream to the next monitoring location. All downstream decay factors within a watershed are linked together by the relative distances that the pollutant loads must travel. After the downstream decay factors have been established, the overall watershed factors are applied to just the loads originating within each subwatershed in order to match the observed median loads. As an example of this source category load estimation process, Table 5-9 shows the Pipe Creek calculations. Each column in the table represents an individual subwatershed identified by the street location of the sampling station at its outlet (for Pipe Creek, there is no sampling station at the confluence with the West Fork White River, so the most downstream subwatershed is identified as “ungaged”). The table shows that, after application of the downstream decay and overall watershed factors, the estimated loads match the observed median loads.

Table 5-9. Pipe Creek *E. coli* Load Estimation and Adjustment Process**Initial Estimated Daily Loads (colonies / day)**

Source Category	CR 600W	CR 900N	CR 1400N	CR 1100N	CR 200W	CR 500W	SR 128	SR13	Ungaged
Manure Application	2.81E+12	3.19E+12	4.18E+13	2.39E+13	4.00E+13	4.34E+13	3.90E+12	5.56E+13	2.20E+12
Active CAFOs	0	0	9.53E+11	0	0	0	0	1.97E+13	0
Domestic Animals	3.31E+10	1.40E+11	3.99E+11	9.69E+11	2.41E+12	1.13E+12	4.38E+11	8.97E+11	3.01E+10
NPDES	0	1.42E+09	1.66E+08	0	5.68E+09	1.11E+09	1.35E+09	0	0
Non-CAFO Livestock	1.09E+11	9.67E+10	1.40E+12	9.29E+11	1.27E+12	1.33E+12	1.06E+11	1.50E+12	7.81E+10
Failing Septic	1.48E+11	6.53E+11	1.75E+12	1.96E+12	6.26E+12	4.02E+12	3.29E+11	2.98E+12	1.36E+11
CSOs	0	0	0	0	9.63E+11	0	4.35E+11	0	0
Wildlife	2.43E+11	3.11E+11	3.57E+12	2.27E+12	4.04E+12	3.94E+12	4.60E+11	4.95E+12	2.05E+11
Totals	3.34E+12	4.39E+12	4.99E+13	3.01E+13	5.49E+13	5.39E+13	5.67E+12	8.57E+13	2.65E+12

Distance to Station (m)	2539	11014	8283	4182	9268	2312	12105	1993	-----
Relative Length	1.00	4.34	3.26	1.65	3.65	0.91	4.77	0.78	-----

Watershed Factor	83.2	61.95	159.5	45.1	6.42	3.982	71	13.45	55.58
Downstream Decay	0.137	0.032	0.042	0.083	0.038	0.150	0.029	0.175	-----

Adjusted Daily Loads (colonies / day)

Source Category	CR 600W	CR 900N	CR 1400N	CR 1100N	CR 200W	CR 500W	SR 128	SR13	Ungaged
Manure Application	3.37E+10	5.15E+10	2.62E+11	5.31E+11	6.23E+12	1.09E+13	5.49E+10	4.14E+12	3.95E+10
Active CAFOs	0	0	5.97E+09	0	0	0	0	1.46E+12	0
Domestic Animals	3.98E+08	2.26E+09	2.50E+09	2.15E+10	3.75E+11	2.84E+11	6.17E+09	6.67E+10	5.42E+08
NPDES	0	2.29E+07	1.04E+06	0	8.84E+08	2.78E+08	1.91E+07	0	0
Non-CAFO Livestock	1.31E+09	1.56E+09	8.79E+09	2.06E+10	1.97E+11	3.35E+11	1.49E+09	1.11E+11	1.40E+09
Failing Septic	1.78E+09	1.05E+10	1.10E+10	4.35E+10	9.75E+11	1.01E+12	4.64E+09	2.22E+11	2.45E+09
CSOs	0	0	0	0	1.50E+11	0	6.12E+09	0	0
Wildlife	2.92E+09	5.02E+09	2.24E+10	5.03E+10	6.30E+11	9.90E+11	6.48E+09	3.68E+11	3.68E+09
Upstream Load	0	5.50E+09	2.41E+09	1.32E+10	5.65E+10	3.23E+11	2.08E+12	6.22E+10	1.12E+12
Subwatershed sum	4.01E+10	7.09E+10	3.13E+11	6.67E+11	8.56E+12	1.35E+13	7.98E+10	6.37E+12	4.76E+10
Cumulative sum	4.01E+10	7.64E+10	3.15E+11	6.80E+11	8.61E+12	1.38E+13	2.16E+12	6.43E+12	1.17E+12

Observed Median Load	4.01E+10	7.64E+10	3.15E+11	6.80E+11	8.61E+12	1.38E+13	2.16E+12	6.43E+12	-----
----------------------	----------	----------	----------	----------	----------	----------	----------	----------	-------

5.6 **DETERMINATION OF SUBWATERSHED SOURCE CATEGORY PERCENT REDUCTIONS**

After subwatershed loads have been estimated and adjusted to observations, percent reduction allocations are made in order to meet the subwatershed reductions identified in Table 5-8. This is achieved through an analysis of the relative percentages of source category loads within each subwatershed and the application of targeted percent reductions to the individual source categories that contribute the greatest loads. Whenever possible, consistency in the level of source category load reductions is preserved across subwatersheds.

As an example of this subwatershed load reduction process, Table 5-10 shows the Pipe Creek calculations. As percent reductions are entered in the percent reduction table, commensurate *E. coli* median load allocations are recalculated in the load allocation table. The relative percent error reflects a comparison of the calculated load allocation with the targeted median subwatershed loads. By keeping all of the percent reductions at round number values, the resultant percent errors achieved are all less than zero, indicating that the cumulative reduced load is less than the targeted median values throughout the watershed. The additional load reduction can be used as part of the margin of safety for this TMDL.

As can be seen from the Table 5-10, large percent reductions in *E. coli* loadings are required from some source categories in order to meet targeted median loads. Percent reductions for *E. coli* loads associated with the agricultural application of manure, non-CAFO and non-CFO related free-ranging livestock, and failing septic systems are all generally higher than 80% and are as high as 99% for some subwatersheds. Other source categories, such as domestic animals, wildlife, and CSOs, also need large percent reductions in *E. coli* loads in selected subwatersheds.

Table 5-10. Pipe Creek *E. coli* Load Allocations and Source Category Percent Reductions

Subwatershed	CR 600W	CR 900N	CR 1400N	CR 1100N	CR 200W	CR 500W	SR 128	SR13	Ungaged
Required % Reduction	91.26%	89.50%	83.62%	86.38%	98.24%	98.50%	90.13%	86.38%	-----
Target Median Load	3.51E+09	8.02E+09	5.16E+10	9.26E+10	1.51E+11	2.07E+11	2.14E+11	8.76E+11	-----

Median Daily Load Allocations (colonies /day)

Source Category	CR 600W	CR 900N	CR 1400N	CR 1100N	CR 200W	CR 500W	SR 128	SR13	Ungaged
Manure Application	1.69E+09	2.58E+09	3.15E+10	3.72E+10	6.23E+10	1.09E+11	2.75E+10	8.27E+10	3.95E+09
Active CAFOs	-----	-----	5.97E+09	-----	-----	-----	-----	7.32E+11	-----
Domestic Animals	1.99E+08	1.13E+09	1.25E+09	1.07E+10	1.87E+10	1.42E+10	3.08E+09	1.33E+09	2.71E+08
NPDES	-----	2.29E+07	1.04E+06	-----	8.84E+08	2.78E+08	1.91E+07	-----	-----
Non-CAFO Livestock	6.53E+07	7.80E+07	1.06E+09	1.44E+09	1.97E+09	3.35E+09	7.44E+08	3.34E+09	1.40E+08
Failing Septic	3.55E+08	1.58E+09	1.65E+09	6.52E+09	1.95E+10	2.02E+10	2.32E+09	6.65E+09	2.45E+08
CSOs	-----	-----	-----	-----	4.50E+09	-----	6.12E+09	-----	-----
Wildlife	1.17E+09	2.01E+09	8.94E+09	2.01E+10	3.15E+10	4.95E+10	2.59E+09	1.10E+10	1.47E+09
Upstream Load	0	4.76E+08	2.49E+08	2.12E+09	6.50E+09	5.47E+09	3.04E+10	2.09E+09	1.47E+11
Subwatershed Sum	3.47E+09	7.39E+09	5.03E+10	7.60E+10	1.39E+11	1.97E+11	4.23E+10	8.38E+11	6.08E+09
Cumulative Sum	3.47E+09	7.87E+09	5.06E+10	7.81E+10	1.46E+11	2.02E+11	7.27E+10	8.40E+11	1.53E+11

Relative % Error	-1.04%	-1.93%	-2.05%	-15.63%	-3.64%	-2.48%	-65.94%	-4.15%	-----
------------------	--------	--------	--------	---------	--------	--------	---------	--------	-------

Subwatershed Percent Reductions

Source Category	CR 600W	CR 900N	CR 1400N	CR 1100N	CR 200W	CR 500W	SR 128	SR13	Ungaged
Manure Application	95%	95%	88%	93%	99%	99%	50%	98%	90%
Active CAFOs	-----	-----	0%	-----	-----	-----	-----	50%	-----
Domestic Animals	50%	50%	50%	50%	95%	95%	50%	98%	50%
NPDES	-----	0%	0%	-----	0%	0%	0%	-----	-----
Non-CAFO Livestock	95%	95%	88%	93%	99%	99%	50%	97%	90%
Failing Septic	80%	85%	85%	85%	98%	98%	50%	97%	90%
CSOs	-----	-----	-----	-----	97%	-----	0%	-----	-----
Wildlife	60%	60%	60%	60%	95%	95%	60%	97%	60%

5.7 CONCLUSION FOR INCREMENTAL WATERSHED LDC APPROACH

The incremental watershed LDC approach was used for this project on an experimental basis. It has been determined that this approach, while having some validity, is not the best approach for TMDLs at this time. With some additional data and information this approach may be viable. However, for the purposes of this TMDL it provides only information for watershed group use. The targets for the TMDL are set in the NPDES and LTCP for the WLA and the reductions table for the LA.